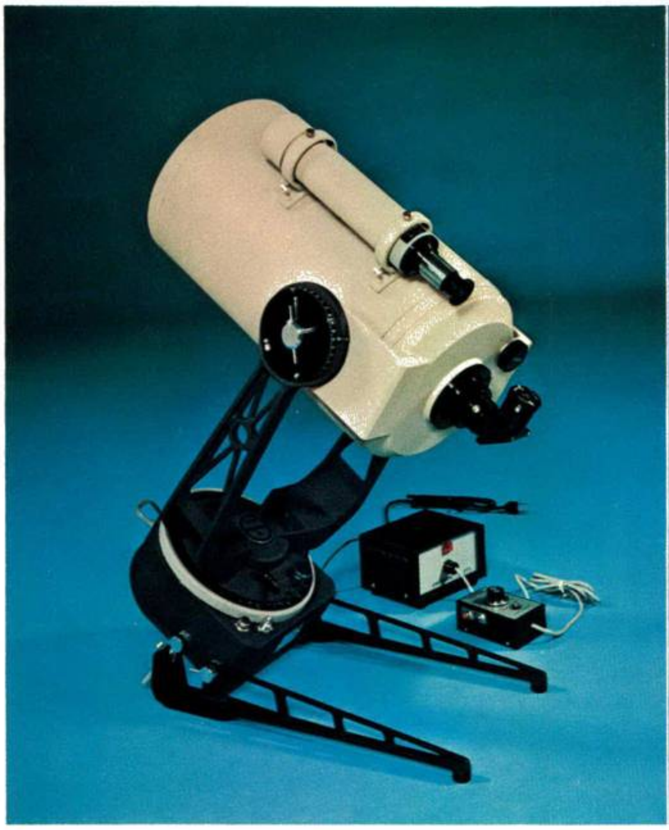
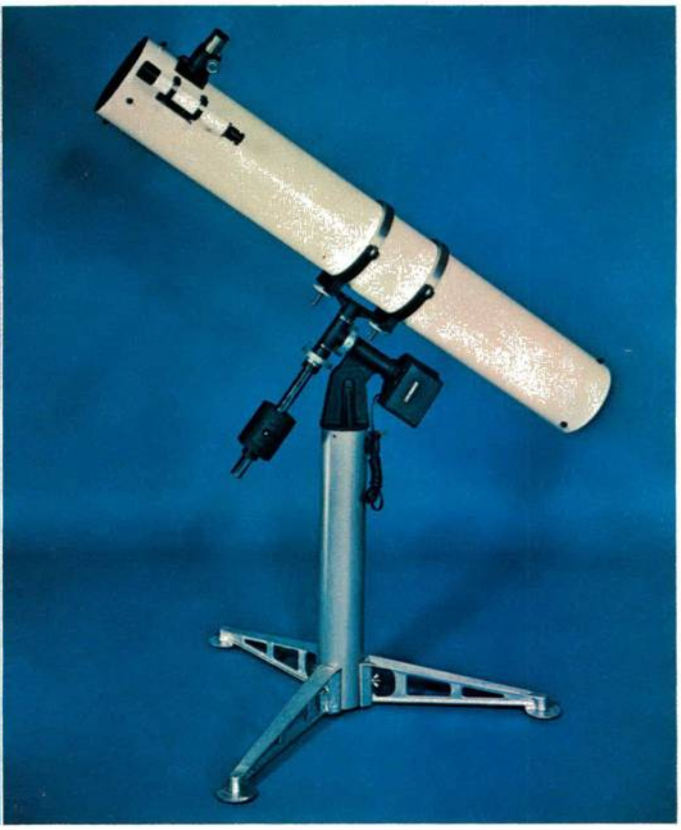
# ASTRONOMY

JUNE 1976 $1.50

# Performance is the First Reason You're Proud to Own a Criterion

In telescopes, "excellence is as excellence does." Our Criterion instruments, with unsurpassed optics, rank among the world's most widely praised, because they perform brilliantly, reliably and with satin-smooth, effortless ease. The more demanding the conditions of use, the more you appreciate the ability of your Criterion to deliver exciting results. Whichever advanced design telescope you select, you get a superbly engineered instrument, guaranteed unconditionally. When you compare the pleasantly surprising prices you find further reason to choose Criterion. Please note that they are not "base" prices, but include everything described AT NO EXTRA COST. Only Criterion's leadership in efficient, modern precision production makes these prices possible.





## Dynamax® 8 8-Inch Schmidt-Cassegrain

**For Spectacular Results—Effortlessly.
Extra Features Without Extra Price.**

This "never before" telescope created by Criterion gives you Schmidt-Cassegrain advantages at their best: full 8" aperture, wide field, with flawless resolution, yet weighs only 30 pounds for one-hand portability! It offers unprecedented versatility for viewing, superb telephotography, terrestrial uses, or technical applications. The exquisite optics, combined with super-precise electric drive plus variable drive corrector, combine to insure unsurpassed, unequalled ease of use because the extra features so necessary for superior results are designed-in and built-in... and INCLUDED in the price! ☐ AC, DC, and manual drives (variable, not just solar). You can easily dial in lunar, solar, sidereal, planetary etc. rates while observing for extra long monitoring. ☐ Large 8x50 finderscope has micrometer screw focusing ☐ Toggle switch with pilot light ☐ Engraved setting circles, observable from viewing position ☐ 3 eyepieces included ☐ Star diagonal, latitude adjusters, photo and telextender adaptors, and custom, fitted case. Ready for Total Performance with nothing else to buy!

As described, complete. FOB Hartford, Conn.
Shipping wt. 65 lbs. Express charges collect.

**$875**

## Dynascope® RV-6 6-Inch Newtonian

**For Exciting Viewing, Superb Value.
Price Includes Built-In,
Precision Electric Drive!**

Professionals and astute amateurs and school or college users by the thousands know the breathtaking performance, this pace-setting telescope achieves. ☐ Exquisite optical system includes f8 parabolic aluminized mirror, guaranteed to reach all theoretical limits of resolution and definition ☐ Highly accurate Electric Drive uses regular AC, has smooth, self-acting clutch, permits manual operation ☐ Two 1¼" eyepieces, 70X and 140X, included. (others available) ☐ Highly stable equatorial mount with solid tripod, adjusts easily for any latitude ☐ Engraved setting circles for both right ascension and declination ☐ Tube rotates for adding cameras and comfortable viewing Easy, quick portability ☐ Smooth, brass rack-and-pinion focusing ☐ Handsome, white 50" Bakelite tube maintains perfect collimation ☐ 6x30 finderscope ☐ Fine workmanship throughout.

As described, complete.
FOB Hartford, Conn. Shipping wt. 77 lbs.
Express charges collect, $15 crating charge.

**$229.95**

To place your order, or request literature, write or call:

**Criterion Manufacturing Company**

**Dept. CPA-22 620 Oakwood Ave., W. Hartford, Conn. 06110/Phone: (203) 247-1696
In New York, Robert T. Little, Eastern Sales Manager (212) 834-1888**

# MEADE Research Quality Telescopes, Parts and Accessories

## 2" O.D. EYEPIECES

Superb wide-angle eyepieces for 2" focusers. Fully coated, premium quality optics for the ultimate in rich-field performance.

**Erfle 32mm** — Highly corrected 5-element optical system, with wide, flat 65° field. **$67.50 ppd.**

**Kellner 60mm**—Low power, long eye relief. Ideal for deep-space observations. **$29.50 ppd.**

## ZOOM EYEPIECES

**Orthoscopic 8.4-21mm (1¼" O.D.)**—Zooms instantly, with excellent image corrections at all powers. 50° field at 8.4mm. **$34.75 ppd.**

**Filter Adapter:** couples our filters to above eyepiece. **$1.00 ppd.**

**Kellner 7.5-22.5mm (.965" O.D.)**—Fine quality, 4-element design. Coated optics mounted in a machined metal housing. **$24.95 ppd.**

## WIDE FIELD EYEPIECES

**Kellner 40mm Extra Wide Field (1¼" O.D.)** Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief. Barrel accepts our filters directly. **$22.75 ppd.**

**Erfle 20mm (1¼" O.D.)** An advanced 5-element system with fully coated, color corrected optics. Fine image quality throughout a wide 65° field. Barrel threaded for our filters. **$24.75 ppd.**

## ILLUMINATED RETICLE EYEPIECE

A professionally-made Kellner 12mm guiding eyepiece for the most discriminating applications. Precisely focusable crossline reticle; remote brightness control with 2 ft. cord. Specify either 1-1/4" or .965" O.D. **$39.95 ppd.**

**Micrometer Reticle:** For accurate measurement of stellar and planetary separations. Interchanges with standard crossline reticle. **$11.95 ppd.**

## PHOTO - VISUAL COLOR FILTERS

Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1-1/4" "Series 1" eyepieces. Filters may be piggy-backed. Listed by Wratten No. and color.

**#8 Light Yellow**
**#11 Yellow-Green**
**#12 Yellow**
**#21 Orange**
**#23A Light Red**
**#25A Red**
**#47 Violet**
**#58 Green**
**#80A Medium Blue**
**Polarizer (30% trans.)**

Each filter **$5.75** ppd. —Set of any 6, **$32.50** ppd.

**Filter Adapters:** Couple our filters to other brands of 1-1/4" eyepieces. Specify brand. **Ea. $1.00 ppd.**

## *Series 1* ORTHOSCOPIC EYEPIECES (1-1/4" O.D.) IN 8 FOCAL LENGTHS

Or. 4mm
Or. 6mm
Or. 9mm
Or. 12.5mm
Or. 25mm

**Now available in .965" O.D. —** These same Series 1 orthoscopics may also be ordered in the foreign standard .965" barrel.

Manufactured to exacting specifications, these excellent orthoscopics will optimize the performance of any telescope. They are of the classical 4-element design, 45° field, fully coated, with precise corrections for color and field flatness. We sell thousands of these Series 1 orthoscopics every year to serious amateurs, universities, and telescope manufacturers throughout the world. There are no finer eyepieces sold for under $25. Barrels are of machined brass, heavily plated, and are threaded to accept our color filters directly.

| | |
|---|---|
| **Focal lengths: 4, 5, 6, 7, 9, 12.5, 18, 25mm** ........ **each** | **$19.50 ppd.** |
| **Set of any 4:** | **74.95 ppd.** |
| **Set of any 5:** | **92.50 ppd.** |

## GUIDE TELESCOPES

For precise guiding during astrophotography. Fine air-spaced achromatic objectives. Rack and pinion focuser, Kellner 9mm crossline eyepiece, and diagonal prism included.

| | |
|---|---|
| **2.4" f/12** | **complete $ 65.00** |
| **3.1" f/15** | **complete $138.00** |
| Brackets for either guide telescope | per pair **$12.75 ppd.** |
| Either guide telescope with Ke12mm Illum. Reticle Eyepiece System | **add $25.00** |

## *Series 1* KELLNER EYEPIECES (1-1/4" O.D.)

The 3-element Kellner design has long been a favorite of amateurs seeking a highly-corrected, yet moderately priced, eyepiece. The 40mm focal length is an exceptionally fine low-cost, wide-field eyepiece. Fully coated. Barrels are threaded for our filters.

K 6mm
K 12mm
K 25mm
K 40mm

| | |
|---|---|
| **Focal lengths: 6, 12, 25mm** | **each $12.75 ppd.** |
| **40mm** | **each $15.75 ppd.** |
| **Set of 4 Kellners** | **$51.50 ppd.** |

## CAMERA ADAPTERS

Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum. For eyepiece projection or first focus. Specify either .965" or 1-1/4" focuser. All 1¼" adapters are threaded for our filters.

| | |
|---|---|
| **Pentax, Praktica, Yashica, Mamiya** | **$16.75 ppd.** |
| **Exakta, Nikon, Canon, Minolta, Miranda** | **$24.75 ppd.** |
| **Olympus OM-1, Olympus Pen** | **$27.75 ppd.** |
| **Adapters only for First Focus** | **$10.75, $14.75, $17.75** |

## MODEL 300 REFRACTOR

Air-spaced achromatic objective. Complete with 5 eyepieces and all accessories. $325.

MOTOR DRIVE
$68.50
ALSO
Model 280
2.4"
Equatorial
Refractor
$189.

## *Research-Grade* ORTHOSCOPIC EYEPIECES (1-1/4" O.D.)

**All our Research-Grade eyepieces are precisely parfocal.**

The very finest in eyepiece design and manufacture. These superb 4-element systems are unsurpassed by any other eyepiece in resolution, color correction, and flatness of field. They are the mainstays of research institutions and observatories everywhere. Fully coated. 45° field.

| | |
|---|---|
| **Focal lengths:6.6, 10, 16, 20, 26.6mm** | **each $29.50 ppd.** |
| **Set of any 4 Research-Grade Orthoscopics** | **$108.00 ppd.** |
| **Set of 4 Research-Grade Orthoscopics plus Erfle 20mm** | **$135.00 ppd.** |
| **Filter Adapter: couples our filters to Research-Grade eyepieces** | **$1.00 ppd.** |

## *Research-Grade* ERFLE 20MM

Manufactured to the same stringent standards as our Research-Grade Orthoscopics, with a wide 75° apparent field. The virtual absence of curvature to the extreme field edge affords truly breathtaking observational opportunities. **$36.50 ppd.**

## PRECISION RACK-AND-PINION FOCUSERS

Carefully machined, all-metal construction. All 3 models include helical-cut rack for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1-1/4" eyepiece holders. *Each focuser is guaranteed to be the finest obtainable in its class.*

**Model #67** — Strong, light-weight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **$14.75 ppd.**

**Model #640** — A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel. Ideal for both visual and photographic applications. **$21.75 ppd.**

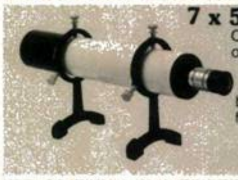
**Model #680**—Our finest focuser. Accepts both 1-1/4" and 2" eyepieces. Full 3" travel, for photo or visual observing with 6" to 16" telescopes. **$29.95 ppd.**

## *Research-Grade* TELENEGATIVE AMPLIFIERS (1-1/4")

The world's finest Barlow lens. Full 26mm clear-aperture achromat, with virtually flawless corrections for chromatic and spherical aberrations.

**2X Model 122--- $29.50 ppd.** **3X Model 123 --- $32.50 ppd.**

## 7 x 50 VIEWFINDER



Coated achromatic objective, 50mm dia. Wide-field crosshair eyepiece. Sharp, brilliant images. (Not for use with prism.) **$27.50 ppd.**

**Brackets: 8.75/pr.**

## 7x50 RIGHT-ANGLE VIEWFINDER

Specifications as above, but for both right-angle and straight-through observation. Crosshair eyepiece, prism included. **$32.50 ppd. Brackets: 8.75/pr.**

## 6 X 30 VIEWFINDER

A fine, wide-field finder. Coated achromatic objective. Crosshair eyepiece. 2-ring bracket included. **$17.95 ppd.**

### COMPLETE CATALOG 76-C — $1.00

Enclose either currency (foreign OK) or U.S. stamps. ($2.00 outside North America for airmail.) All catalogs are sent by return First Class Mail. **Catalog free with any order.**

Name ______________________________

Street ______________________________

City ______________________________

State ____________________ Zip __________

master charge THE INTERBANK CARD

Your BANKAMERICARD welcome here

**MEADE INSTRUMENTS**
721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281

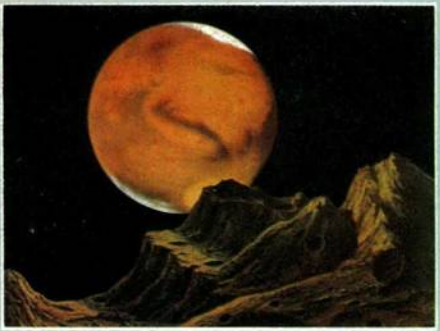
**MEADE INSTRUMENTS**
721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281

TELEPHONE ORDERS ACCEPTED
*(SORRY, NO COLLECT CALLS)*

# Reprints — Posters — Calendars

## *From ASTRONOMY*

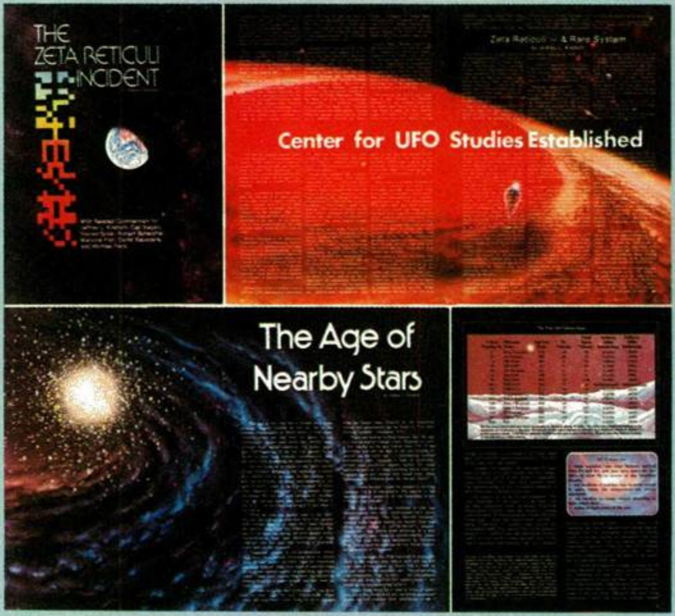
### Mars as Seen From Deimos



Actual Poster Size: 17" x 22"

**$1.75 each**

Painted by Victor Costanzo, this authentic, artistic rendition is set against a real star background as though Mars were in the constellation Taurus. Full color, varnished, suitable for framing. All posters listed here are insured and mailed in a heavy duty mailing tube.


THE ZETA RETICULI INCIDENT
Center for UFO Studies Established
The Age of Nearby Stars

### The Zeta Reticuli Incident Reprint

Size: 8-1/4" x 11-1/4

**$4.00 each**

This exciting reprint combines, in one 32 page source, articles and commentary that appeared in ASTRONOMY which documented the astronomical implications of an alleged star map seen aboard a UFO by Betty and Barney Hill. While not offering incontrovertable proof that alien visitors to Earth live on a planet circling the star Zeta Reticuli, the astronomical detective work is persuasive. Commentary is provided by scientist Carl Sagan and Steven Soter as well as Jeffrey Kretsch, Robert Scheaffer, Marjorie Fish, David Saunders and Michael Peck. Full color, illustrated throughout, varnished cover.

### Milky Way in Sagittarius

Actual Poster Size: 17" x 22"

**$1.75 each**

Photograph made by Orien A. Ernest using a home built cold camera shows clusters, nebulae and star clouds in true relationship to each other and to the constellation Sagittarius' teapot asterism. Better than a star atlas of this sky region, the photograph reveals in dramatic reds, golds and blues, objects you can easily find with your naked eye or binoculars. Varnished, suitable for framing, mailed in a heavy duty mailing tube, insured.

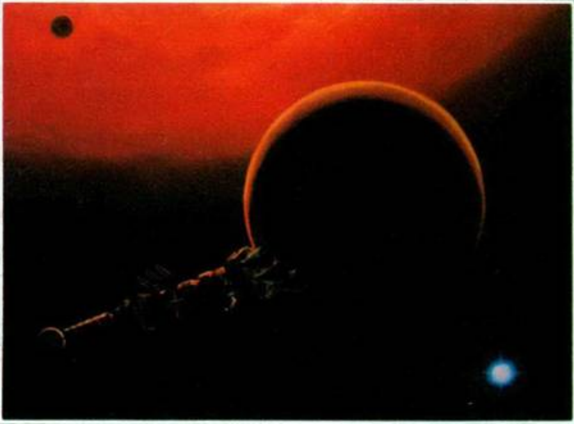
### ASTRONOMY 1976 Sky Almanac

Opened Size: 11" x 17

**$5.50 each**

This 28 page calendar was designed exclusively as a vehicle to carry full color, varnished reproductions of some of the best art and photographs that have appeared in ASTRONOMY. Complete framing instructions are provided for the 12 full color illustrations. It also contains maps of each month's sky — useful in any year. An almanac of 1976 sky events is included along with introductory level observing projects.

### Exploration of Antares Star System



Actual Poster Size: 22" x 34"

**$3.50 each**

Painted by John Clark, this imaginative rendition shows a 21st century starship exploring a scorched Earth sized planet and its moon in orbit about Antares. The red super giant star looms ominously, filling most of the sky while Antares' blue-white dwarf star companion is seen at lower right. Full color varnished, framable.

| Quan. | Item | Price | Total |
|---|---|---|---|
| | Mars as Seen From Deimos | @ $1.75 | $ |
| | Milky Way in Sagittarius | @ $1.75 | $ |
| | Antares Lithograph | @ $3.50 | $ |
| | ASTRONOMY 1976 Sky Almanac | @ $5.50 | $ |
| | Zeta Reticuli Incident Reprint | @ $4.00 | $ |
| ADD FOR HANDLING/POSTAL INSURANCE PER ORDER | | | $ .50 |
| Send Check or Money Order to:<br>ASTRONOMY, 757 N. Broadway, Suite 204,<br>Milwaukee, WI 53202 | | Order Total | $ |

Date: ______________

Name ______________________________
(Please Print)

Address ______________________________

City ______________ State/Prov. ______________ Zip ______________

Orders are usually shipped within two (2) weeks, but please allow six (6) weeks for delivery.

# ASTRONOMY

**The World's Most Beautiful Astronomy Magazine**

June 1976 Vol. 4, No. 6

**PUBLISHER and EDITORIAL DIRECTOR**
Stephen A. Walther

**EDITORIAL**
**Managing Editor**
Penny Oldenburger

**Technical Editor**
Richard Berry

**Editorial Assistant**
Henry J. Phillips

**Staff Associate**
Kenneth Engel

**Consulting Editors**
James Mullaney
John Harmon

**GRAPHICS**
**Production Manager**
David A. Schwartz

**CIRCULATION**
**Subscriber Relations**
Rosemary L. Pickart

**COMMUNICATION**
**Information Officer**
Penny Oldenburger

6 ASTEROIDS
*by David Morrison*
13 1976 AA: DISCOVERY OF A MINOR PLANET
*by Eleanor F. Helin and Eugene M. Shoemaker*
14 FRAGMENT FROM A YOUNG ASTEROID?
*by Donald Bogard*
18 GAZER'S GAZETTE
Viewing the Full Moon
*by Richard Berry*
27 EQUIPMENT ATLAS
What You Can See Through A Small Refractor
*by Henry J. Phillips*
32 ASTRONOMY REVIEWS
34 PHOTOGRAPHY IN ASTRONOMY
Photograph the Milky Way
*by Hal Jandorf*
42 Setting Up An Astrodarkroom
*by Richard Berry*
49 SKY ALMANAC
Planets Go A.W.O.L.
57 ASTRO-MART
59 ASTRO-NEWS
65 GUIDE TO BACK ISSUES
66 JUNE STAR DOME
*by James Mullaney and Henry J. Phillips*
72 Close-Up on the Serpens Caput Region
72 Eyepiece Impressions
76 PLANET FINDER — JUNE 1976
79 JULY SKY MAP

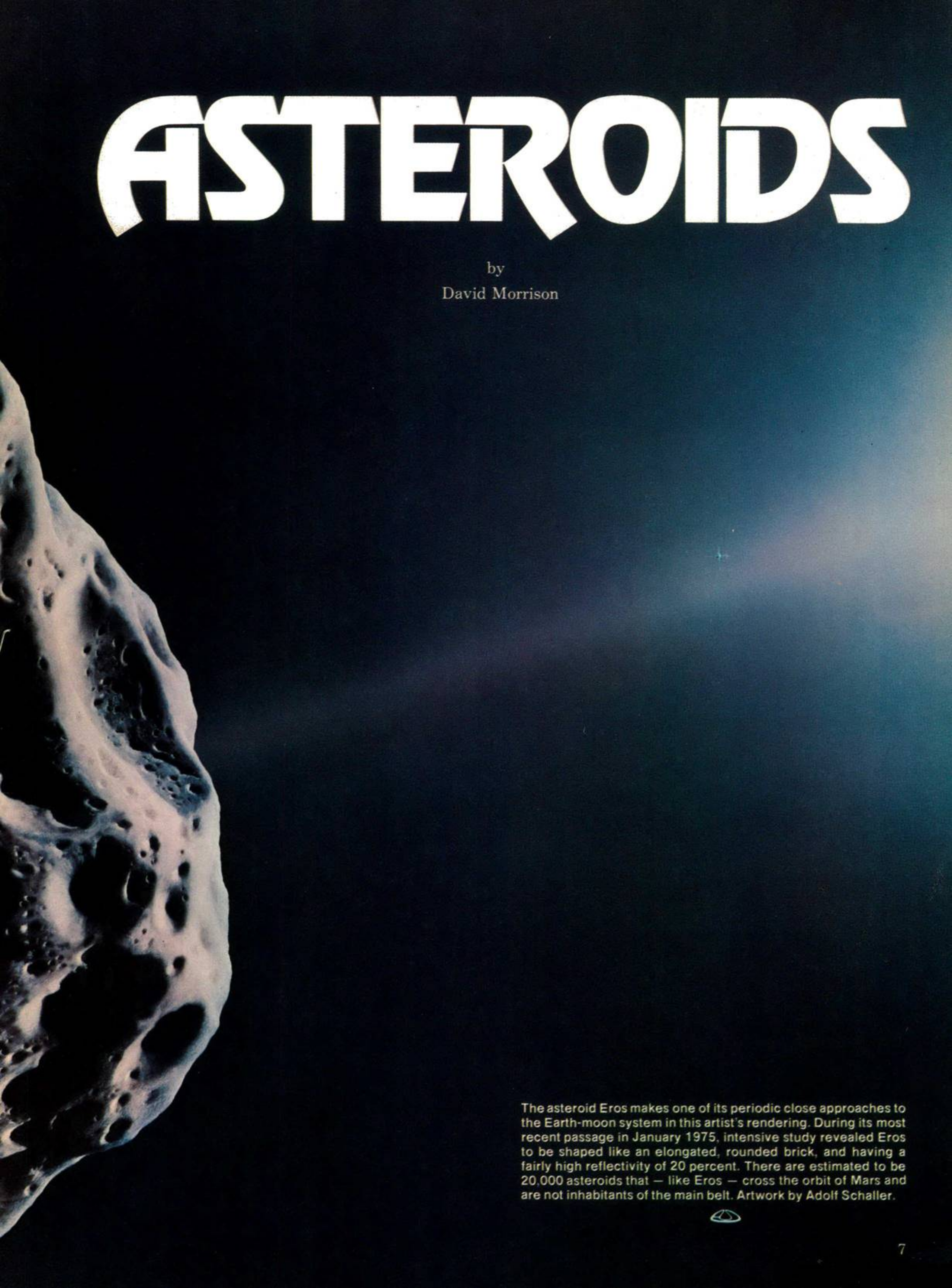
Cover

The phenomenon known as aurora can be completely explained in terms of solar flares, particles penetrating Earth's magnetic field, and interactions with molecules high in Earth's atmosphere. Having said all this, it must be added that a mere clinical explanation cannot possibly describe an aurora's breathtaking beauty and exquisite detail. A period of major solar activity during the latter days of March produced bright auroral displays, making possible photographs like the one reproduced on this month's cover. This shot, aimed at the zenith, was made on High Speed Ekrachrome through a 35mm f/1.8 lens. The aurora fans out from an overhead point, dropping in shimmering streams on the horizon. Photograph by Randy Borst.

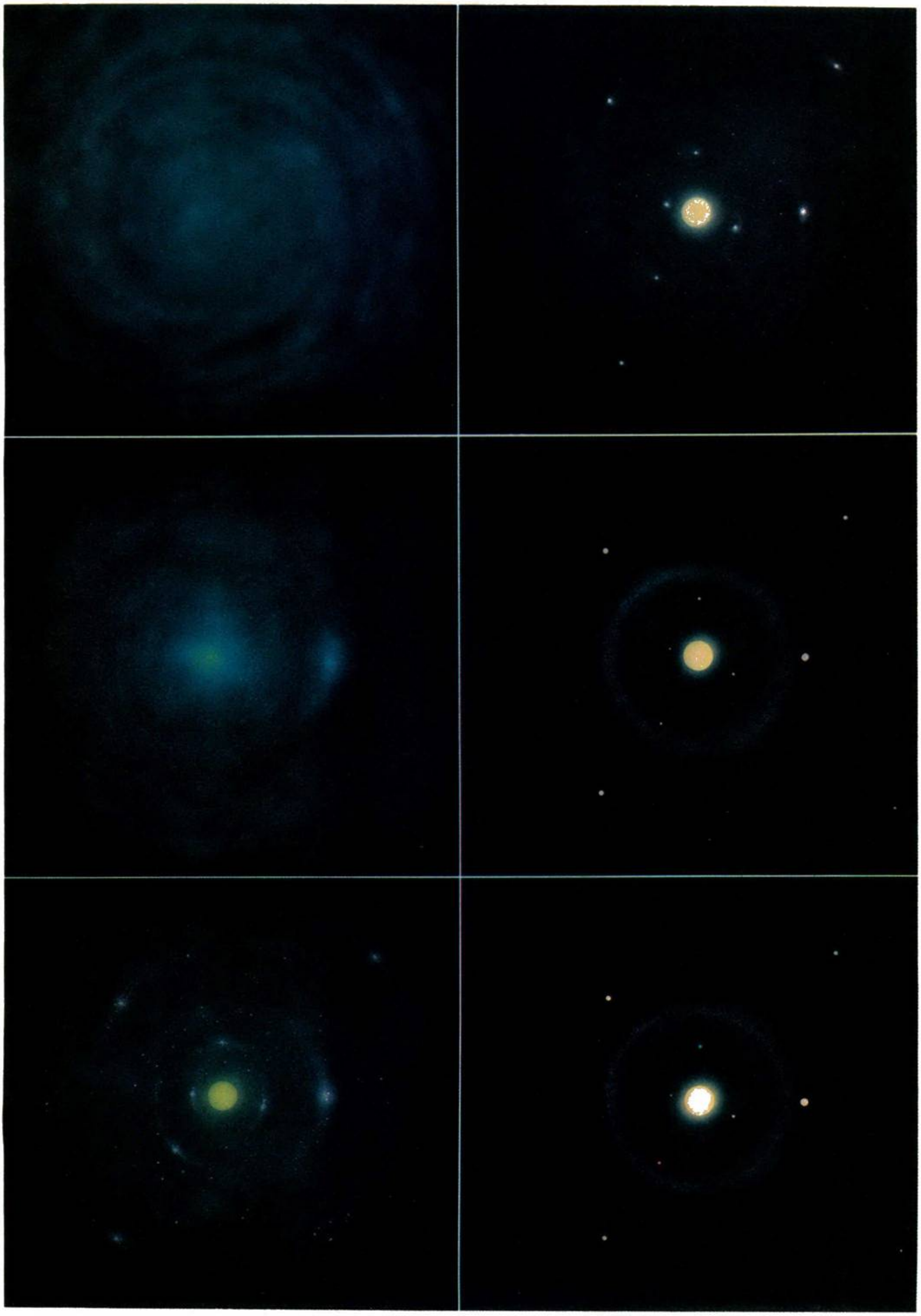
Published monthly by AstroMedia Corp., 757 N. Broadway, Suite 204, Milwaukee, WI 53202. Copyright© 1976 by AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or otherwise copied for public or private use without written permission of the publisher. Second class postage paid at Milwaukee, Wisconsin. POSTMASTER: When undeliverable, send form 3579 to publisher. Direct all new subscriptions, changes of address, renewals and subscription bill payments only to ASTRONOMY, Circulation Services, P.O. Box 186, Westchester, IL 60153 and allow six to eight weeks for new subscriptions and changes of address to take effect. To speed service on subscription correspondence, complaints, photographs, slides, manuscripts and editorial correspondence write ASTRONOMY, 757 N. Broadway, Suite 204, Milwaukee, WI 53202. Telephone (414) 276-2689. Due to the limited availability of back issues, new subscriptions must start with the most current month's issue. Cover price, $1.50. Subscription price: 1 year, $12.00. Canada & Mexico: add $3.00 per year. All other foreign: add $6.00 per year. Additional office staff: William Stanfield, Production Assistant; Katherine King, Editorial Secretary; Stephanie Kiel, Administrative Assistant; Nancy Faustmann, Bulk Copy Sales. Accountant: Peter Trabbold. Contributing Editors: Thomas C. Bretl, James E. Oberg, Gerrit L. Verschuur. Contributing Artists: John W. Clark, Victor Costanzo, Adolf Schaller. ADVERTISING REPRESENTATIVES: Western Region — J. E. Publishers' Representative Co., 8732 Sunset Blvd., 4th Floor, Los Angeles, CA 90069; (213) 659-3810. Eastern Region — J. E. Publishers' Representative Co., 527 Madison Ave., New York, NY 10022; (212) 355-6875. Typesetting by Grafilm, Inc., Milwaukee, WI 53210. Separations prepared by American Color Systems, New Berlin, WI 53151. Printed by E. F. Schmidt Co., Menomonee Falls, WI 53051.

# ASTEROIDS

by
David Morrison



The asteroid Eros makes one of its periodic close approaches to the Earth-moon system in this artist's rendering. During its most recent passage in January 1975, intensive study revealed Eros to be shaped like an elongated, rounded brick, and having a fairly high reflectivity of 20 percent. There are estimated to be 20,000 asteroids that — like Eros — cross the orbit of Mars and are not inhabitants of the main belt. Artwork by Adolf Schaller.



Four and a half billion years ago, in a spinning, collapsing cloud of gas and dust on the outskirts of our run-of-the-mill spiral galaxy, a star was being formed... around it, millions of smaller condensations were also forming, colliding, sticking together as they swept up grains of dust from the swirling nebula. Many collisions fragmented the growing bodies, scattering their material back into the cloud; but, on the average, they grew larger. Within an incredibly short time on the cosmic clock — perhaps a few million years — most of the solid material had grown into planetesimals several hundred miles in diameter (large enough to have significant gravitational fields). When they passed close to each other, they tended to coalesce into even larger bodies, since they bumped together very slowly. Within several hundred million miles of the rapidly heating protosun, a few planetesimals grew by absorbing their smaller neighbors into the bodies that we today call the terrestrial planets. But farther out — around 500 million miles from the center — a particularly large planetesimal reached such a size that it could attract not only solid material but also the abundant gases in the nebula. It rapidly grew to hundreds of times the size of the inner protoplanets, and the tug of its gravity began to influence the entire nebula. This giant, of course, would eventually be known as Jupiter.

The planetesimals near the new giant began to have a hard time. They were pulled by both the protosun and proto-Jupiter, and their nearly circular orbits were disturbed into ellipses of increasing eccentricity and inclination. On these new orbits, when one planetesimal chanced to encounter another, their relative speeds were high enough that the collision was catastrophic; instead of coalescing to form a larger object, they shattered into many smaller pieces. Exposed in the middle of a cosmic shooting gallery, their growth into a planet was arrested almost before it could begin. Instead they embarked on an irreversible path to destruction, with nearly every collision breaking down the larger bodies into smaller fragments. For hundreds of millions of years these fragments were scattered throughout the solar system, and today in the highlands of the moon and Mercury we see the cratered desolation that resulted from this rain of rocks.

What is left now, billions of years later, of this material that never was able to form a planet? Most of it is gone — some was kicked by the powerful gravitation of Jupiter completely out of the solar system; some fell on the surfaces of Mercury, Venus, Earth, the moon, and Mars; some fell into the sun or into Jupiter itself. But a small percentage remains, approximately where it always was, between the orbits of Mars and Jupiter. These remnants are called the *minor planets*, or *asteroids*.

**Several current theories of asteroid formation generally follow the outline depicted here. At upper left, minute dust grains form in the protosolar system nebula. Next, larger bodies build up slowly as these dust grains collide at low velocities, eventually (bottom left) forming planetesimals from the slowly depleting cloud of dust and gas. These planetesimals, perturbed by the proto-Jupiter (upper right), begin to collide at speeds high enough to break them into smaller pieces. By the time the major planets had formed (right center), many smaller bodies were scattered throughout the solar system, occasionally impacting and cratering the larger bodies. Today, most of this debris has been removed, and most of the asteroids are contained in a belt that lies between Mars and Jupiter. Artwork by Victor Costanzo.**

The above sketch describes a plausible scenario for the origin of both the asteroids and the heavy early cratering of the surfaces of the inner planets. But it is not easy to reconstruct events so far in the past; uncertainties and doubts remain. Let's look at what we know about the asteroids, to investigate the evidence for this picture of their origin.

The first and largest asteroid was discovered on the first night of the 19th century by Guiseppe Piazzi, a Sicilian monk. Piazzi was making a star map, so he had to carefully record the positions of the stars in his telescopic field. The next night, returning to this same field, he found one "star" had moved, and the third night it had moved an equal distance again. At first Piazzi thought he had found a comet, but the new object moved more slowly than a comet would, persistently retaining its crisp, starlike image. After many nights of tracking its motion, Piazzi felt confident he had discovered a new planet. He suggested that it be named Ceres, after the patron goddess of Sicily.

Piazzi's planet, so fortuitously found, was almost lost again. After a few weeks of following its motion, Piazzi became ill and could not continue. Postal service then being even slower than it is now, his letters describing the new planet did not reach other observers in time for them to pick up the planet that year. Attempts were made to construct an orbit from Piazzi's positions, but the computational techniques of the day were not up to the challenge. It seemed as if Ceres was surely lost — an inconspicuous wanderer among the myriad stars.

In Germany, however, news of the discovery and apparent loss of Ceres came to the attention of the brilliant young mathematician, Karl Friedrich Gauss. Gauss had been working on methods of calculating orbits from limited observational material. Welcoming the chance to try his new techniques on this object, Gauss calculated an orbit and predicted new positions. Another German, Wilhelm Olbers, then went to his telescope to check the prediction and located Ceres in October 1801, on his first try.

Both Gauss and Olbers went on to make many contributions to astronomy and physics — but, little else of importance is attributed to Guiseppe Piazzi.

Between 1802 and 1807, three more of the little planets were found, all at about the same distance — 2.8 astronomical units (AU) — from the sun. These were also named for goddesses (Juno, Pallas and Vesta), setting a precedent of female names for asteroids that has persisted until nearly the present day. Asteroids are also numbered in order of discovery, and it is common practice to refer to an asteroid by both number and name, as in 1 Ceres.

The new planets were indeed minor. Ceres is only seventh magnitude at its brightest — about two times fainter than the dimmest star visible without a telescope. Only Vesta can occasionally become bright enough to be seen with the naked eye, but identifying it against the background of stars without optical aid is quite difficult. In addition, we know now that the diameter of Ceres is only 600 miles, and all of the asteroids together have less than the moon.

The next minor planet wasn't discovered until nearly a half century later. After a 15 year search, German astronomer Henke was rewarded with the discovery of Astraea in 1845. In 1847 three more asteroids were found, and not a year has passed since then without several new discoveries. In the second half of the 19th century, asteroid hunting became a major sport among astronomers, and almost every observer of note seems to have discovered at least one. Many previously obscure observers gained public recognition, monetary rewards, and an entrance to careers in astronomy as a result of their diligence at the telescope.

Especially after the introduction of photographic searches in the 1890s, the number of known asteroids grew rapidly. Today almost 2,000 are numbered, named and followed. These orbital calculations are made primarily at Cincinnati University and at the University of Leningrad. Thousands of others could be found and added to the list if astronomers felt there was much to be gained from the enterprise.

Most asteroids circle the sun between the orbits of Mars and Jupiter, at distances from the sun of 2.2 to 3.3 AU. This region of the solar system is often called the *asteroid belt*. However, the science fiction picture of this belt as a region densely (and dangerously) filled with asteroids and their debris is incorrect. In fact, asteroids lead lonely lives, rarely passing within a million miles of each other. When Pioneers 10 and 11 traversed the belt in 1972 and 1973 en route to Jupiter, their instruments never came within sighting distance of a single asteroid.

We have discussed the discoveries and locations of minor planets, but what are they? How big are they? What are they made of? If you landed on one in a spacecraft, what would it be like? Only very recently have we begun to find answers to these questions.

The largest asteroids — those 100 or more miles in diameter — are nearly spherical. Whatever their initial shape, the force of their own gravity smooths them into balls. But many smaller asteroids, when watched over a period of several hours, show variations in brightness — sometimes by as much as a factor of two. These variations are due to the rotation of irregular, lumpy objects. The larger the light variation, the more elongated is the object. The jagged shapes of so many small asteroids suggest that they are fragments, formed in violent collisions.

In the 1890s, the first attempts were made to measure the angular diameters of the largest asteroids. The 36 inch telescope at Lick Observatory, then the largest in the world, was used. But the often quoted results were uncertain for a simple reason: Asteroids are so tiny that it is extremely difficult, even with a fine telescope, to see their disks. It is the absence of apparent disks that gives them the name asteroid, meaning starlike.

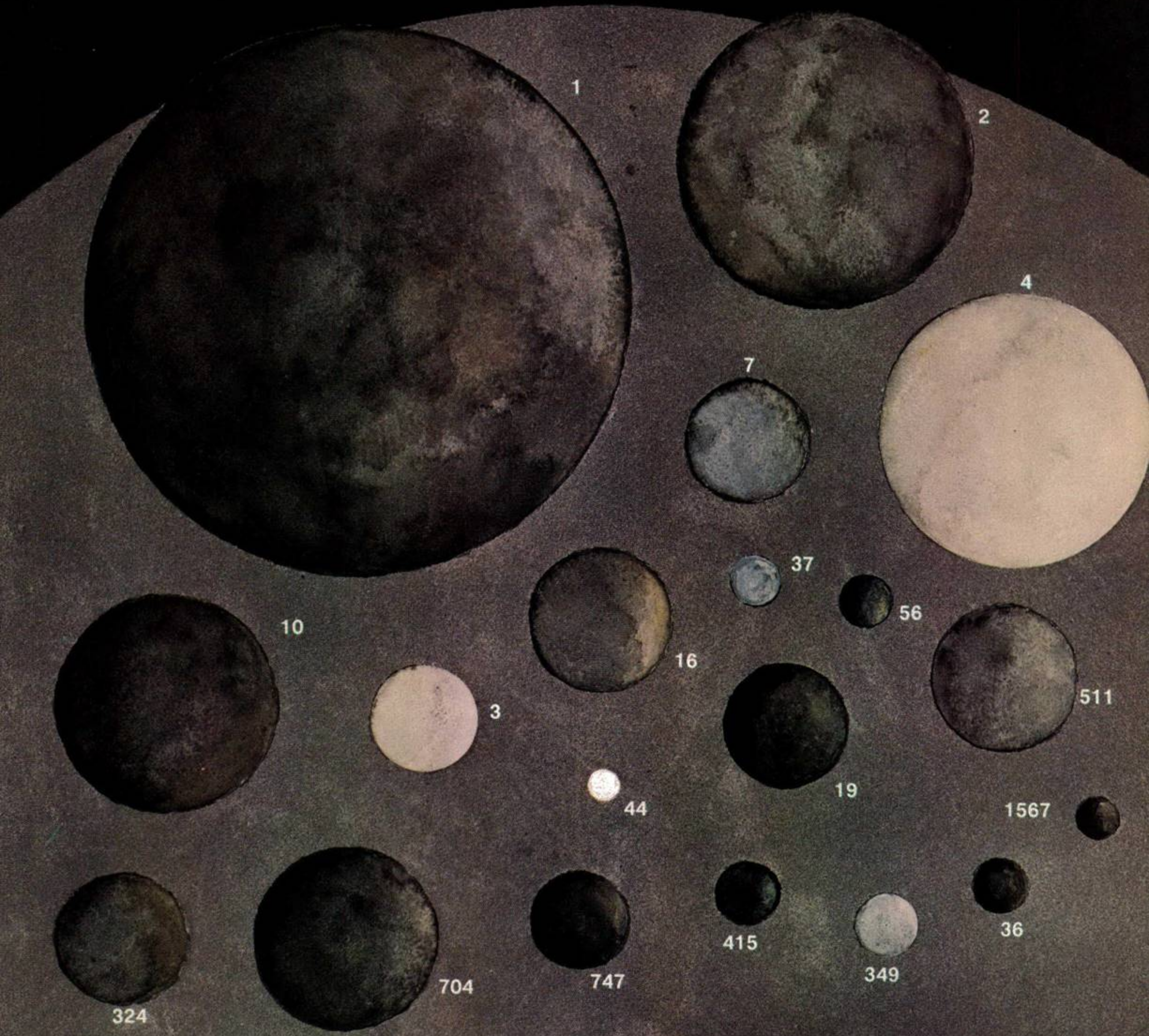
Something of a watershed in asteroid research took place in 1970; the subject was Vesta, the brightest of the asteroids. In that year, two entirely new techniques of calculating the diameter of a small body — one based on polarization measurements and the other based on the amount of infrared radiation it emits — were invented. These techniques, when applied to Vesta, yielded a diameter both larger and more accurate than that deduced visually in the 1890s. With a diameter of just over 300 miles, Vesta is the third largest asteroid. In the same year, Massachusetts Institute of Technology astronomers Tom McCord, John Adams and Torrence Johnson reported the spectral reflectivity of Vesta; this reflectivity showed a distinct spectral signature — that of basalt, the same sort of volcanic rock that fills the lunar maria. The type of basalt on Vesta's surface appeared identical to that in a rare type of meteorite called a basaltic achondrite. Could these meteorites be chips off Vesta? To try to answer this question, measurements of many other asteroids were required.

The three new observing techniques first used on Vesta in 1970 have now been applied to more than 200 asteroids. As a result, scientists have at last begun to see how large the asteroids are and what their surfaces are made of. These exciting developments are currently making the study of asteroids one of the most important areas of planetary research.

One result of this work is the demonstration that the asteroids are very different — not only from the planets, but from one another. As has so often proved to be true in the solar system, when we look closely at any object, we learn to appreciate its uniqueness. For example, consider the asteroids' reflectivity. In the past, before accurate measurements existed, astronomers could do little but assume that all the asteroids reflected a similar

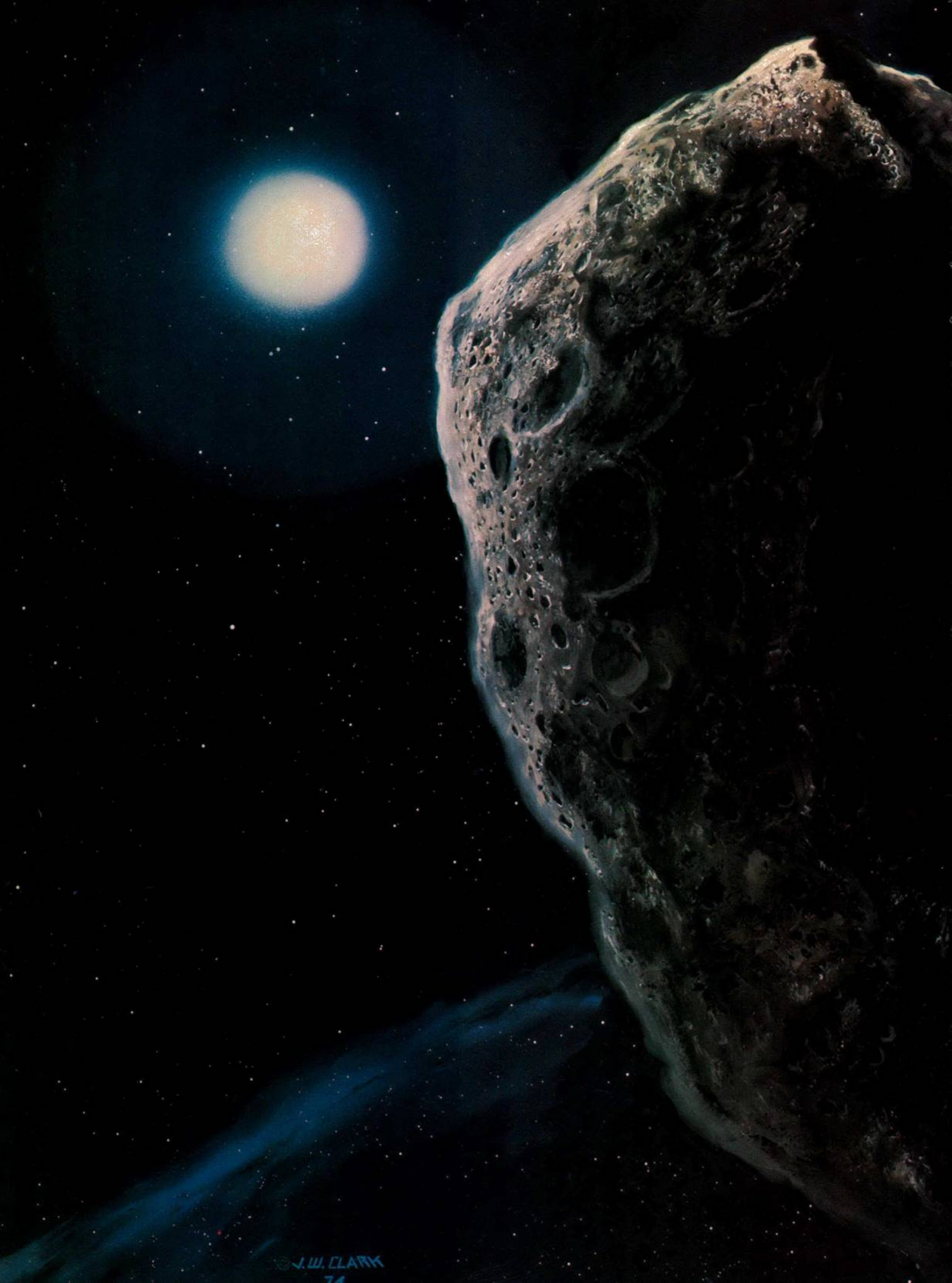
**As this artist's rendition shows, asteroids vary greatly in size and reflectivity. Nineteen of the largest asteroids are drawn here to the same scale; the brightest are nearly white, while the darkest reflect the same amount of light as lumps of coal. Smaller asteroids are much too small to be portrayed in a diagram of this size. For comparison, Earth's moon has been placed in the background: It has a 2,060 mile diameter and 12 percent reflectivity. Artwork by Mark Paternostro.**

# ASTEROIDS:
# Size and Brightness


1
2
4
7
37
56
10
16
511
3
19
44
1567
415
36
349
704
747
324

| | | Diameter (miles) | Albedo |
|---|---|---|---|
| 1 | Ceres | 600 | 6% |
| 2 | Pallas | 350 | 9% |
| 3 | Juno | 140 | 19% |
| 4 | Vesta | 310 | 26% |
| 7 | Iris | 125 | 18% |
| 10 | Hygiea | 240 | 5% |
| 16 | Psyche | 150 | 9% |
| 19 | Fortuna | 140 | 3% |
| 37 | Fides | 56 | 18% |

| | | Diameter (miles) | Albedo |
|---|---|---|---|
| 56 | Melete | 70 | 4% |
| 44 | Nysa | 45 | 45% |
| 511 | Davida | 170 | 6% |
| 324 | Bamberga | 145 | 4% |
| 704 | Interamnia | 200 | 3% |
| 747 | Winchester | 110 | 3% |
| 415 | Palatia | 80 | 3% |
| 349 | Dembowska | 90 | 24% |
| 36 | Atalante | 75 | 3% |
| 1567 | 1941 HN | 45 | 3% |


©J.W. CLARK
74

# 1976AA: DISCOVERY OF A MINOR PLANET

by Eleanor F. Helin and Eugene M. Shoemaker

The first newly-discovered object to be reported in this year's International Astronomical Union circulars, 1976 AA, was initially seen on Jan. 7, shortly after midnight PST. Unlike most other Apollo asteroids that approach Earth closely, 1976 AA was not found by accident. We had been conducting a systematic search for Apollo asteroids with the 18 inch Schmidt telescope at Palomar Observatory since January 1973. Our goal was to estimate the total number of planet-crossing asteroids, as well as to learn more about their physical characteristics, their origin, and the frequency with which they collide with the planets. Several lines of evidence make it clear that Apollo asteroids are the parent bodies of most meteorites falling on Earth. It is also becoming increasingly clear that many, if not most, of the Earth-crossing asteroids are the stony cores of dead or degassed comets.

Among the dozen asteroids discovered, 1976 AA is by far the most unusual. With a semimajor axis slightly less than one astronomical unit, a period slightly less than one year, and a fairly small eccentricity, its orbit comes closer to the orbit of Earth than that of any other known object in the solar system except our moon. It is thus one of the easiest bodies to reach by spacecraft, and a particularly inviting target for a manned mission.

With the propulsion systems being contemplated at NASA for use by the 1990s, it may be possible for men to visit 1976 AA in 1995, when it again will be close to Earth. Because 1976 AA is only about 2/3 mile (1 km) in diameter, as shown by radiometric and polarimetric observations by astronomers at the Universities of Arizona and Hawaii, a landing on the asteroid would be similar to a docking with another spacecraft. No elaborate landing system would be required to touch down on its surface. Indeed, astronauts, while walking on the surface, would have to be careful not to step too vigorously lest they launch themselves into space. A possible safety measure can be borrowed from mountain climbing techniques: Astronauts could rope themselves directly to the asteroid.

One of the main scientific objectives of such a mission would be a search for clues about the early growth stages of solid bodies in the solar system. If 1976 AA is the silicate core of a former comet, as is suspected, a detailed investigation of its structure may reveal the method by which small particles condensed directly from the solar nebula and aggregated into larger bodies — the planetesimals. What mixtures of different kinds of particles are there in a body like this? Are these bodies aggregates of aggregates? If so, how large are the various subunits from which the whole body is made? Were some aggregates smashed by impact subsequently re-forming into new aggregates? How frequently? These and many other questions might be resolved if experienced observers could map the surface structure of what is essentially a "fossil" planetesimal at different scales, and bring back abundant samples of its different components for laboratory study on Earth.

We estimate that the number of Earth-crossing asteroids 2/3 mile in diameter or larger is presently between 400 and 1,200. Continual shifting of their orbits, caused by the gravitational attraction of the planets, could bring many of these asteroids into collision paths with Earth or the moon. A great many have apparently collided in the past reaching typical speeds of about 15 miles per second. A body of meteoritic material 2/3 mile in diameter traveling at this speed will make a crater about 11 miles across. Such a collision crater is produced on Earth's land areas on the average of once every million years. If the orbit of 1976 AA is perturbed randomly, it has 1 chance in 24 of hitting Earth sometime during the next million years. If it strikes a land surface, it will produce a crater about 8-1/2 miles in diameter.

---

*Eleanor Helin, discoverer of 1976 AA, is a senior scientist in the Division of Geological and Planetary Sciences at California Institute of Technology; her current specialty is the investigation of Apollo asteroids. Eugene M. Shoemaker is professor of geology at Caltech for six months of the year. For the remainder, he is a geologist with the United States Geological Survey. His main field of study is impact craters on terrestrial planets.*

## Fragment From a Young Asteroid?

by Donald Bogard

Most asteroids are believed to be primitive objects, in the sense that minerals and other chemical compounds within them formed early in the solar system's history and have not been subsequently modified. The observation that Earth, the moon and most meteorites are approximately 4.5 billion years old gives indirect evidence of the asteroids' antiquity. Meteorites are small, stony or metallic objects which fall on Earth when their orbits about the sun intersect that of Earth. Many scientists believe that meteorites have been derived from asteroids by collisional fragmentation, but it is unknown whether their parent objects are Apollo asteroids, main belt asteroids, or some other class.

An extremely rare type known as Nakhlites (named after Nakhla, a stone that fell in Egypt in 1911) belongs to the achondrite class of stone meteorites. According to several meteorite investigators, achondrites were formed by crystallization from molten rock or magma. Vesta seems to be an asteroid with an achondrite-like surface, although apparently not of the Nakhlite type. Until recently only two Nakhlites were known to exist, and there has been some debate whether they truly represented two different meteorites. (The specimen from Lafayette, Ind., was accidently "discovered" in a private mineral collection.)

Now a third Nakhlite has been identified, and like the other two, it has a "young" formation age. The 158 gram (5.57 ounces) Governador Valadares meteorite was found in Brazil in 1958, but it was only in 1975 that it was identified as a Nakhlite, from petrographic and chemical determinations made by three investigators at the University of Rome.

Governador Valadares was formed only 1.25 billion years ago, as was reported last March at the annual meeting of the Division of Planetary Science. The meteorite's age was determined by the relatively new argon-40/argon-39 technique — a sophisticated version of potassium-argon dating. An age of 1.25 billion years was calculated for Governador Valadares, making it one of the youngest extraterrestrial objects known — nearly two billion years younger than the youngest known lunar basalt.

How Nakhlites were formed such a short time ago is an intriguing and unanswered question. Only two mechanisms seem likely, and both have serious difficulty. Nakhlites may have formed if radioactive elements sufficiently heated an asteroid's interior so that surface melting and a flow of basalt occurred. Such an origin, however, would require either a very large asteroid or unusually high concentrations of radioactive elements, leaving open the question as to why other types of achondrite meteorites are not as young. Alternatively, Nakhlites may have formed in a major collision between two asteroids, possibly in the asteroid belt. Evidence exists that the parent bodies of many chondritic meteorites may have suffered such collisions. It remains unclear whether a major collision could produce sufficient liquid melt for a long enough time to permit Nakhlite type objects to form.

The Nakhlites, including Governador Valadares, have existed in space as small objects for only about eight million years — a length of time determined from concentrations of the nuclear products of cosmic ray interactions. The collisional event (or events) that excavated them from their parent asteroid was probably not a major one; because of its relatively recent occurrence, it most likely took place nearer the orbit of Earth than in the asteroid belt. Thus, an asteroid with a young, Nakhlite type surface composition may now be in orbit near Earth. It would be a fascinating object to identify.

proportion of the light falling on them — perhaps close to the moon's 12 percent. But now we know that there is a range of more than a factor of 10 in asteroid reflectivities. The highest value measured so far is for 44 Nysa, which has a reflectivity of between 40 and 50 percent — about the same as that of many icy moons of Jupiter and Saturn. At the opposite extreme are many remarkably black asteroids; among the largest of these are Hygiea, Davida, Interamnia, Europa and Cybele. These remarkable objects reflect only three or four percent of the sunlight striking them — about the same amount as a lump of coal! Clearly, the asteroids are not all made of the same stuff!

A definite relationship exists between reflectivity and composition. The darkest asteroids do not show prominent spectral features, and the combination of low reflectivity and flat spectra suggest they are like the carbonaceous class of meteorites which, like coal, are dark because of the presence of carbon compounds. Since carbon is one of the most abundant elements in the universe, its presence is not surprising — except for its apparent rarity on the surface of the terrestrial planets. Nearly all the brighter, more reflective asteroids show *spectral structure*. For the most part, the features indicate the presence of silicate (rocky) materials — the sort of chemical compounds of silicon, oxygen, iron, magnesium, aluminum and other common rock-forming elements that we might expect on any planetary surface.

There are, however, a few odd objects. The very reflective Nysa, for instance, appears from its spectrum to be depleted in iron. Ben Zellner of the University of Arizona, who first identified the high reflectivity of this object in early 1975, suggests that it may be composed of a rather unusual, highly transparent mineral called enstatite. And of course Vesta, with its surface of volcanic basalt, is remarkable. In five years of searching, no other asteroid with this composition has been found. At least among the larger asteroids, Vesta is clearly unique.

Most of the large asteroids are of the low reflection, carbonaceous variety. Since they reflect so little light, they are not as bright as their more reflective cousins — but we should not overlook them. The largest asteroid, Ceres, although not so dark as many (its reflectivity is six percent), is in this group, as is Pallas. Of the 18 asteroids larger than 150 miles in diameter, 15 are carbonaceous.

One of the most fascinating relationships to emerge in the last few years combines the asteroids various compositions with their distances from the sun. In the inner part of the belt, near the orbit of Mars, almost all asteroids are of the light, stony type. But as we probe outward, there is a greater percentage of the dark ones — until at the outer edge of the belt, more than three AU from the sun, about 80 percent of the asteroids are carbonaceous.

It makes sense to assume that these compositional differences reflect variations in the original material that condensed out of the solar nebula to form the asteroids. The differences must indicate that inner and outer asteroids are still at about the same distance from the sun that they were at the time they formed, making the asteroids a potentially powerful probe of the conditions that existed at the time of the solar system's formation. It also shoots down the old theory, still occasionally revived, that asteroids are the remnants of a single "exploded" planet. Such a giant explosion surely would have mixed up the fragments terribly. There are also other problems with the exploded planet idea. For example, the dark carbonaceous surface material on most asteroids would have been destroyed in a planetary interior. Also, calculation of orbits indicates that the asteroids probably could not have originated from a single event in time and space. In fact, asteroids are the leftovers of creation — fragmented but still in place, waiting to be analyzed.

But how can astronomers analyze asteroids? Sending a space probe out to collect and return a piece of even one would be extremely expensive. To sample a large number of these objects seems prohibitive with today's reduced space program. Nature, however, may have already provided us with samples of asteroids: meteorites.

Stones from the sky pelt Earth continually. Occasionally a really big piece — one that weighs thousands of tons — strikes with catastrophic consequences. The most recent such event took place about 25,000 years ago in Arizona, leaving the mile-wide explosion pit we now call Great Meteor Crater. Such events which release an energy equivalent to the largest hydrogen bombs are fortunately rare. But smaller rocks drift in all the time, and about once a year a meteorite is seen falling and is subsequently recovered in North America. Perhaps a thousand "falls" have been recovered throughout the world, along with many additional meteorites that have not been seen to fall. Increasingly, scientists believe that most of these meteorites are chips off asteroids.

The surfaces of many asteroids show reflection spectra similar to meteorites. These include the carbonaceous chondrites, basaltic achondrites, and enstatite achondrites. It's very tempting to conclude that we already have on our museum shelves the samples we would so much like to analyze.

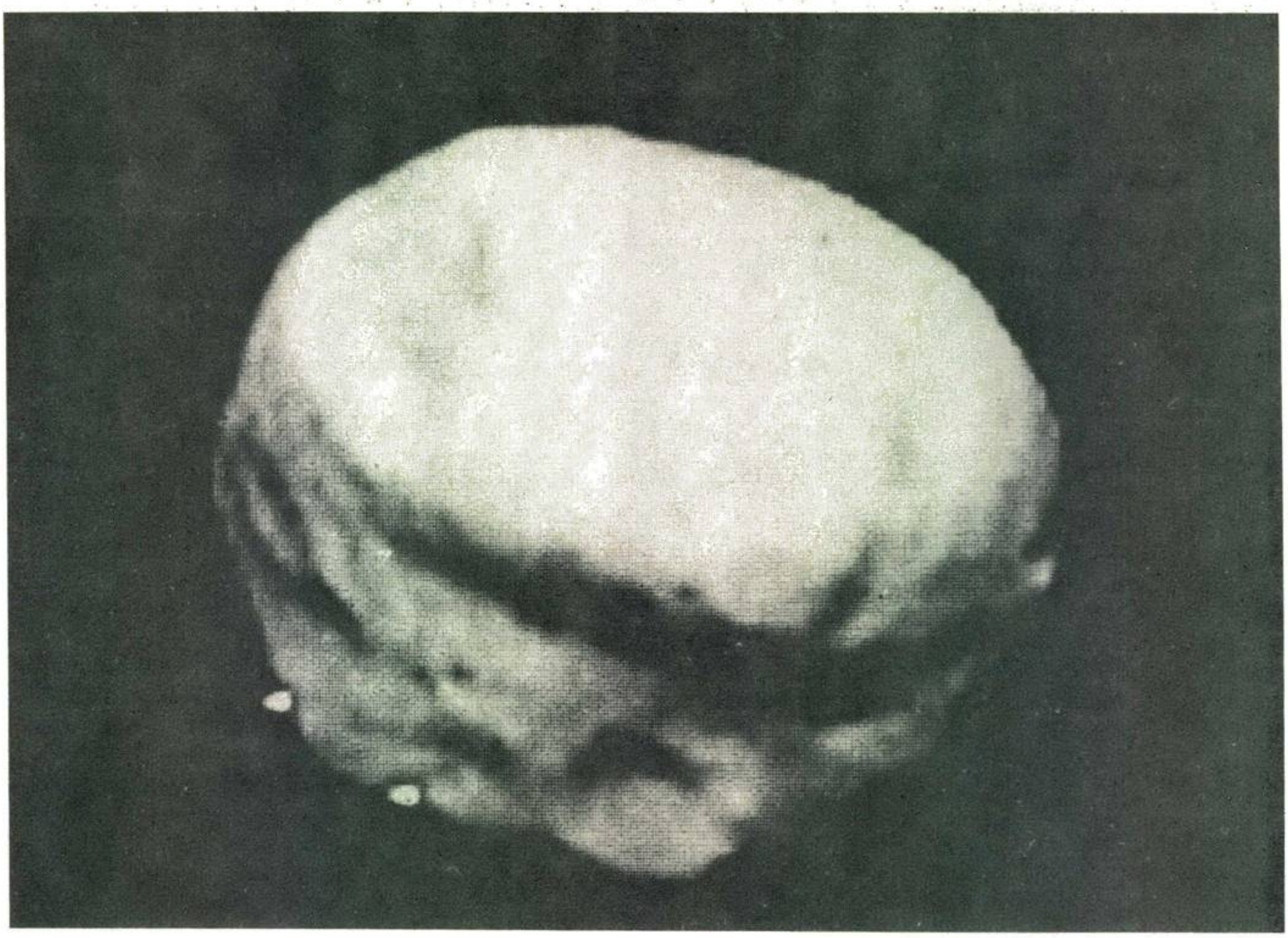
But carbonaceous chondrites and enstatite achondrites are rare types of meteorites. What about the most familiar sorts: ordinary stony chondrites and iron-nickel meteorites? Do these come from the asteroid belt too? The answer is probably yes. In 1975, spectra of asteroid 349 Dembowska showed that its surface resembles the ordinary stony chondrites. And scientists such as Ben Zellner and his colleague Clark Chapman, of the Planetary Science Institute in Tucson, increasingly suspect that a number of reddish tinged asteroids of moderately low reflectivity are metallic in composition, like the nickel-irons. The brightest of these are 16 Psyche and 22 Kalliope. Psyche is currently the subject of observations being carried out at several observatories, but conclusive evidence one way or another on its composition is not yet in.

So far we have considered only the asteroids that populate the main belt. But there are a small number that venture beyond these confines, and they are among the most interesting of the minor planets.

In 1906, scientists discovered an asteroid located about five AU from the sun — in practically the same orbit as Jupiter! Because of its peculiar orbit, the tradition of bestowing a feminine name was not followed, and this distant world was called Achilles. Within the next two years, Patroclus, Hektor and Nestor — all in similar orbits — were discovered, and today hundreds of these bodies are known. The brightest are named for Greek and Trojan heroes from Homer's **Iliad**, and collectively they are known as the *Trojan asteroids*. They are clustered near Jupiter's orbit in two loose clouds — one preceding the giant planet in its orbit by about 60 degrees, and the other following at an equal distance. These peculiar orbits are stable, as first shown by the French mathematician Lagrange, and the points in space leading and trailing a planet by 60 degrees are called the *Lagrangian points* of its orbit.

Within the past two years, the first measurements have been made of the larger Trojan asteroids' physical properties. They've turned out to be reddish in color and very dark, with reflectivities of only about three percent. Thus their surfaces are unlike those of any other measured asteroids, and unlike any meteorites as well. Probably no samples of Trojan asteroids are in meteorite collections, and we don't know what these bodies are made of. They are distinct not only from the main-belt asteroids, but also from the faint, outer satellites of Jupiter. This is evidence for the stability of asteroid and satellite orbits, since these objects do not seem to have been shuffled about from one orbit to another.

Other asteroids stray inward from the belt, crossing the orbit of Mars and occasionally approach-



**The moons of Mars may resemble asteroids quite closely. About 15 miles in diameter and with a five percent albedo, Phobos was photographed by Mariner 9, showing a large cleft and several craters. NASA photograph.**

ing Earth. These objects are especially interesting because, in spite of their small size, they sometimes come close enough to be fairly bright and easily studied. Also, we have a natural proprietary interest in anything that approaches Earth, and these asteroids are our closest neighbors after the moon.

A particularly well-observed Mars-crossing asteroid is 433 Eros (again, the masculine name indicates this is not a main-belt asteroid). Discovered in 1898, Eros is so small that it would hardly be noticed out in the main belt. But every few years it nears Earth, and becomes one of the brightest asteroids in the sky. Its closest passage to Earth during this century — a mere 15 million miles — took place in January 1975. For several weeks a number of optical, radio and radar telescopes were directed toward Eros before it sped away into a few more years' obscurity.

Studies showed Eros to be an elongated, rough fragment, a mere chip off some larger parent body. The asteroid is shaped rather like a rounded brick, with dimensions of 8 x 9 x 22 miles. It has a reflectivity of 20 percent — rather high as asteroids go. Although no one has ever seen it closely enough to resolve surface features, we can safely assume that Eros is rough and cratered. It probably looks a good deal like Phobos, Mars' somewhat smaller and darker moon.

Modern estimates indicate there are perhaps 20,000 Mars-crossing asteroids larger than a half mile across. Yet even this large number is a tiny fraction of the number of similar sized objects thought to inhabit the main asteroid belt.

For every 2,000 to 3,000 Mars-crossing asteroids, there's one that strays even farther from the main belt so that, near perihelion, its orbit intersects that of Earth. These rare objects are called *Apollo asteroids* after the first member of the group. Discovered in 1932, Apollo was named for the sun god because it came closer to the sun than any other known asteroid. A few years later an Apollo asteroid was found that not only crossed the orbits of Mars and Earth, but continued sunward to a point inside Mercury's orbit. This tiny body, about a mile in diameter, was named Icarus for the legendary aviator who flew so close to the sun that the wax holding his wings together melted, sending him plunging to his death.

Twenty Apollo asteroids — out of an estimated total of about 1,000 — have actually been observed. Since the largest is only a couple of miles in diameter, they can be seen only when they are quite close to Earth. Discovered on photographic plates by the telltale streak produced by their rapid apparent motion, they must be recognized and followed during the few days that pass before they speed past Earth and become lost in the vast reaches of space. They are quite difficult to observe, and many Apollo asteroids have been lost after one passage, with their orbits so poorly known that it is doubtful they will be picked up again except by chance.

The chances that one of these Apollo asteroids will someday strike Earth are actually very good, provided we wait long enough. It appears that every few million years, an object a half mile or more across strikes either Earth or the moon. In the distant past, of course, such impacts must have been more frequent. But in a sort of selection process, many of the Apollo asteroids that we see still exist because they avoid too-close encounters with Earth. A particular example is asteroid Toro — locked into an orbit that resonates with the orbits of Venus and Earth in a way that prevents it from coming very close to either planet.

How did all the variety in compositions come to exist among the asteroids? Part of the explanation probably lies in the differing conditions in various parts of the solar nebula from which the original planetesimals formed. At greater distances from the protosun, where it was cooler, materials that remained in gaseous form farther in could solidify. According to many scientists, the reason that dark carbonaceous asteroids exist mostly in the outer belt — but few of this type are found in the inner belt and none (so far) among the Mars-crossing or Apollo asteroids — is that temperatures were too close to the protosun for the dark, carbon-bearing materials to condense. Since the time of formation, of course, there has been a certain amount of mixing up of individual objects, but not enough to erase completely the chemical imprint of conditions in the nebula that existed long ago.

Simple temperature differences within the early solar nebula are not sufficient explanation for the great variety in the asteroids' surface materials or in all the types of meteorites that strike Earth. Other processes must have been at work to mold the asteroids' raw material into such exotic forms as basaltic achondrites (the surface of Vesta), enstatite achondrites (the surface of Nysa), or nearly pure iron-nickel (possibly identified on Psyche and Kalliope). The missing ingredient needed to work this transformation is heat — or, more specifically, reheating after the asteroid is formed.

The chemically primitive material, such as that which forms the most common meteorites, must have once existed in the interiors of the asteroids or their parent bodies, the planetesimals. When heated to the melting temperatures of rocks, these materials change. Light gases, including abundant water vapor, are driven to the surface and escape into space. Heavy metals sink under their own weight to the center, and other minerals segregate themselves according to their density and chemical nature. This process of melting and separation is called *differentiation.* All the terrestrial planets have differentiated, and so have the larger satellites. But have the asteroids also been differentiated? Apparently some have been, and some haven't been.

The most obviously differentiated asteroid is Vesta. With its surface of basaltic lava, Vesta must have once had a molten interior. Its present interior most likely includes an iron-nickel core, a mantle of rock, and a surface of ancient lava. But no other asteroid with a surface like Vesta's has been found, and we must turn to more circumstantial evidence to decide if other asteroids have shared Vesta's past history.

If we could unequivocally identify a metallic asteroid, it too would have to be the product of differentiation. And indeed, the iron-nickel meteorites must come from differentiated parent bodies.

The importance of collisions has recently been pointed out by Clark Chapman. In the thickly populated asteroid belt of several billion years ago, collisions were frequent and broke up the early, differentiated parent bodies, exposing and releasing this core material. Chapman suggests that more than four billion years ago, about 100 of these parent bodies existed, each with a core of metal — but, almost all of them have been shattered by collisions and their fragments scattered throughout the solar system. Some of their cores may remain as metallic asteroids. But only one single parent body, of all those that once existed, has survived relatively intact — Vesta. It's almost as if nature preserved this lone example of a once-common resident of our solar system to allow us to reconstruct the events of the past from it.

Whatever the details of the past evolution of the asteroids — and a number of those details are now in dispute — it appears inescapable that at least Vesta, and probably many other asteroid bodies, were once melted. In contrast, the numerous dark, carbonaceous asteroids — including Ceres, the largest — surely did not melt. If they had ever been really hot, their dark carbon compounds would have evaporated and they too would have covered themselves with lava. Why some large asteroids should have once melted, while others equally large and nearby in space should have survived intact, is one of the most profound mysteries now confronting anyone attempting to understand the formation and early evolution of our planetary system.

---

*Dr. David Morrison is an astronomer at the Institute for Astronomy of the University of Hawaii. Currently on leave at the University of Arizona and Kitt Peak National Observatory, his primary interests are infrared observations of planets, satellites and asteroids. He is also involved in exploration of the solar system by spacecraft. His book,* **Minor Planets and Satellites,** *will be published in mid-1976.*

GAZER'S GAZETTE

# Viewing the Full Moon

by
Richard Berry

For a few days before and after full moon, the familiar rough, cratered surface takes on a dramatic new appearance. Craters become pale rings, no longer standing in vivid shadowed relief; mountain chains become white bands of light, and the maria seem to fade in the intense glare. At that first blinding glance into the eyepiece, there would seem to be nothing to see at full moon.

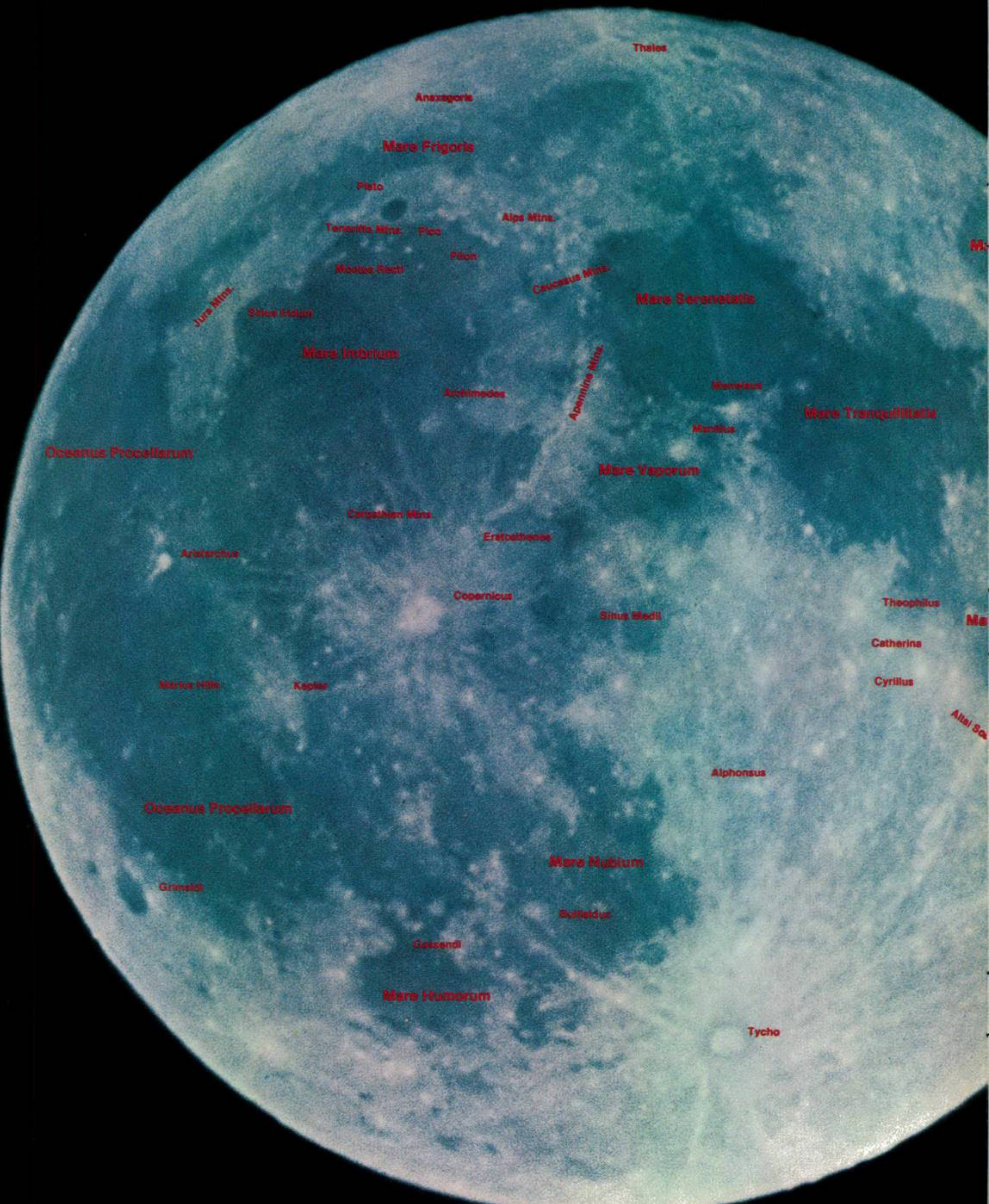
The rays of Tycho are the first feature you'll probably see when you adjust to the brilliance, along with the dark necklace of maria that covers about half the visible surface. Tycho's rays are directly visible to sharp eyed observers, but binoculars show long streaks of bright material that cross or cover everything in their path. Careful examination with a telescope shows they aren't really continuous but consist of overlapping blobs that converge at Tycho. Near Tycho, the rays disappear; in fact, the crater is surrounded by a dark halo, which in turn is surrounded by a bright ray halo. Tycho is a "young" crater formed a quarter of a billion years ago; its walls are still crisp and sharp. The crater itself is bright — one of the brighter spots on the moon — lunar soil that is freshly disturbed on a cosmic timescale. Just south of Tycho, one ray is particularly striking because it doesn't point straight back toward the crater as most of the others do. If you look closely, you'll see that skewed rays are common.

Copernicus vies with Tycho for glory at full phase. It is blindingly bright at this time: Its interior walls show concentric scarps as does Tycho, and the crater rim is a thin, bright line. Its brilliant rays lie on a dark mare surface, providing a striking contrast. But none of Copernicus' rays can compete with the gigantic Tycho rays that cross nearly half the moon's diameter. Copernicus is a youngster too — perhaps a mere 800 million years old.

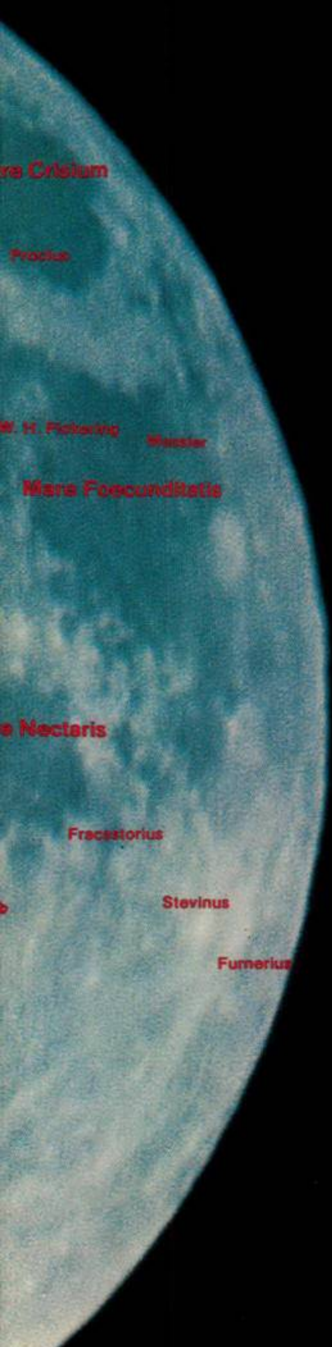
Copernicus is a prototype large impact crater. The rays consist of hordes of minute craters and blocks of dust and rubble thrown out from the impact. New material, exposed to the sun for only a billion years, is brighter than the ancient lunar surface. After about two billion years, the rays and bright craters eventually darken and fade — as the old ray system around Eratosthenes is doing.

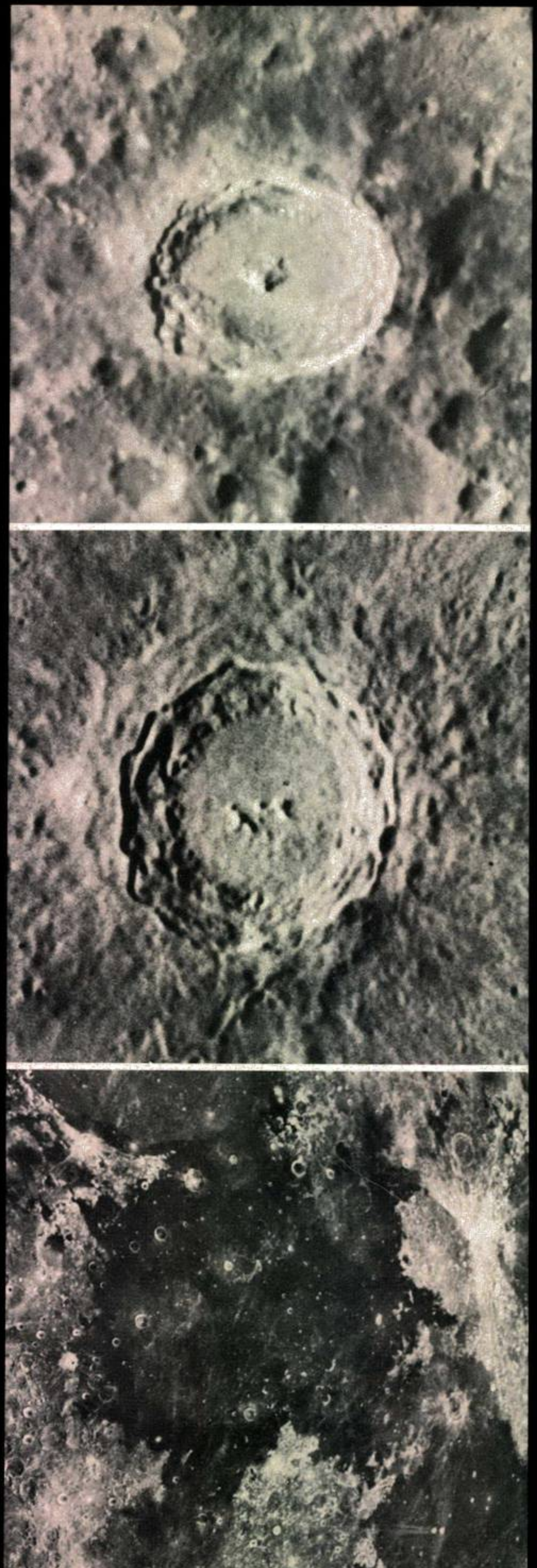
Furnerius and Stevinus, two small craters near the western limb of the moon, contribute another extensive ray system. One ray sweeps east across Mare Nectaris, while another heads south nearly halfway to Tycho. For such tiny objects, these two craters have truly impressive rays. On the eastern limb, Kepler and Aristarchus both spread their rays across the surface of Oceanus Procellarum. Aristar-

**This slightly underexposed photograph of the full moon shows the ray systems, lunar maria, and bright craters to best advantage. Fuji R-100 film developed in Kodak E-4 chemicals was used with a Celestron 8 at f/10; the exposure was 1/250 second. Photograph by Leonard Smith.**


Thales
Anaxagoris
Mare Frigoris
Plato
Teneriffe Mtns.
Pico
Alps Mtns.
Piton
Montes Recti
Caucasus Mtns.
Jura Mtns.
Sinus Iridum
Mare Serenetatis
M
Mare Imbrium
Apennine Mtns.
Archimedes
Menelaus
Mare Tranquillitatis
Manilius
Oceanus Procellarum
Mare Vaporum
Carpathian Mtns.
Eratosthenes
Aristarchus
Copernicus
Sinus Medii
Theophilus
Ma
Catherina
Cyrillus
Marius Hills
Kepler
Altai Sc
Alphonsus
Oceanus Procellarum
Mare Nubium
Grimaldi
Bullialdus
Gassendi
Mare Humorum
Tycho

Map photograph by Alan Dyer.


re Crisium
Proclus
W. H. Pickering
Messier
Mare Foecunditatis
e Nectaris
Fracastorius
b
Stevinus
Furnerius



Close-up views of Tycho (top) and Copernicus (middle) show these craters under moderately high solar illumination. The few shadows remaining will help you identify the crater details at full. In the bottom photo, Mare Tranquillitatis is shown in a high contrast rendition showing brightness features that are difficult to see with the naked eye. Try using it as a guide for visual observing. Lick Observatory photographs.

chus is the brightest crater on the moon at full, and although it loses its searchlight brilliance at other times of the lunar day, it remains one of the brightest areas at all phases.

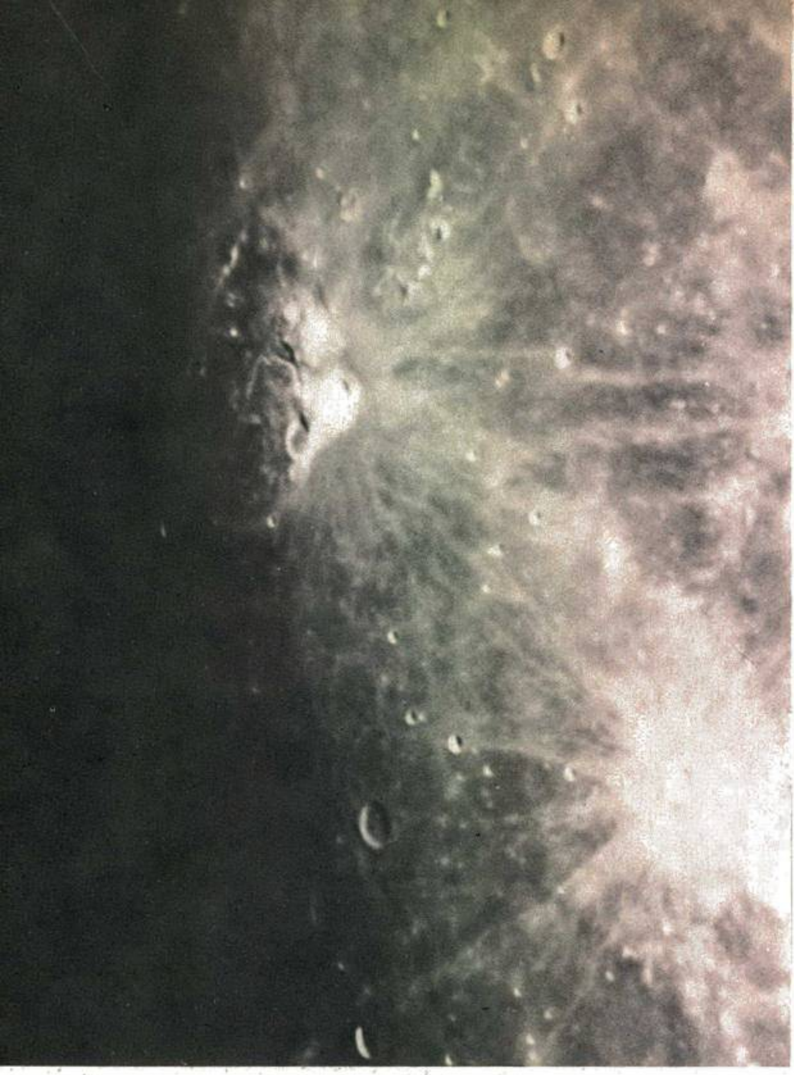
Many more craters — dozens, in fact — show ray systems: Anaxagoras, Procus, Thales, Byrgius and Olbers, to name just a few. Some are very odd: Messier and W.H. Pickering, on the floor of Mare Foecunditatis, have a strange cometlike double ray that is very conspicuous at high power. In Orbiter photos of the moon, these craters are unusual too, and may be the scar of a grazing asteroidal impact event.

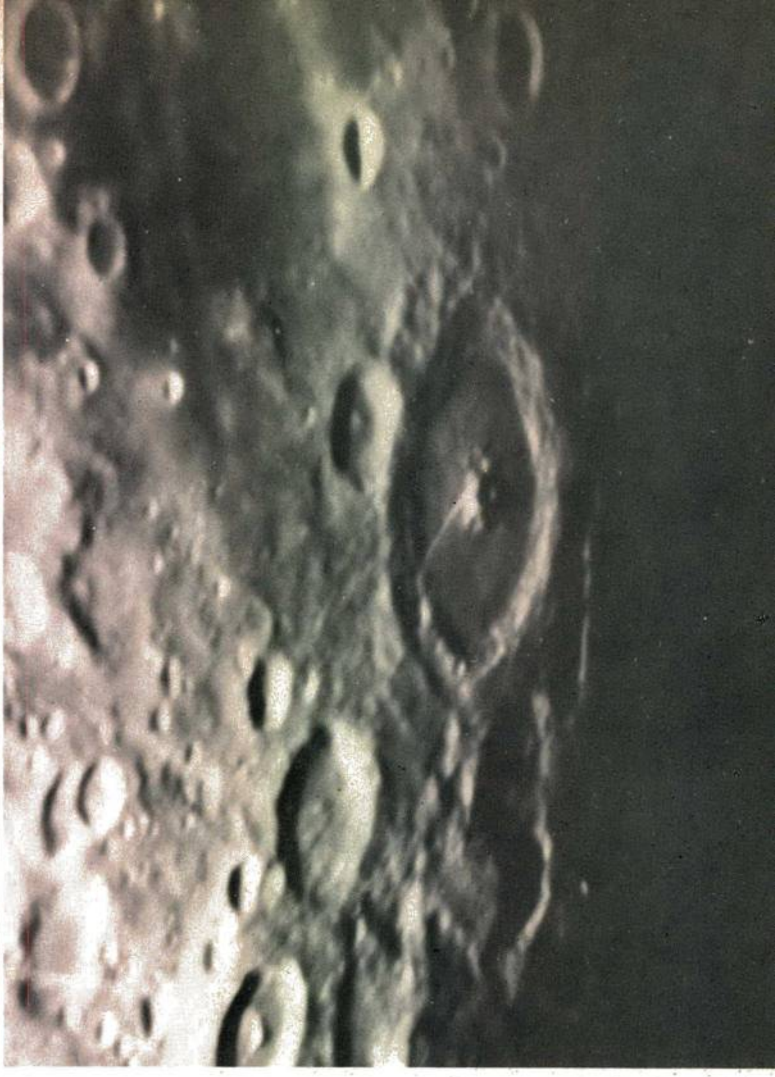
If you can ignore the maria and ray systems of the giant craters for a while, even a quick examination of the full moon will show that it is peppered with brilliant, almost starlike bright spots, and that many darkish marelike gray patches appear away from the maria in the floors of the bigger and older craters. The bright spots, of course, are small craters, and often you'll be able to see they aren't spots but rings. They show up especially well on mare surfaces, but the intensively cratered southern highlands are covered with them too. The relatively "new" character of the lunar rock in their walls makes them shine brightly. At full moon, the sun's light is reflected back to Earth from a surface that acts like a reflector road sign or beaded projection screen. At the other phases, the intense return beam misses Earth and the new rock looks like the older gray crater walls.

**The unique beauty of the full moon has stirred the creation of countless bits of legend and folklore. To the eyes of western man, the familiar "man in the moon" is probably the most common perception, with his jolly leer providing a friendly sight as he rises over the horizon on warm summer evenings. This photograph, made with a 400mm lens at f/6.3, exemplifies the special attraction that the full moon has held for all peoples in all times. Photograph by Haruhisa Koyama.**

Theophilus is an unusually large bright ring crater. Its interior slopes form a thin bright ring with a central bright spot — the fresh material on its central peak. Just south of Theophilus are the much older Catherina and Cyrillus, with their walls battered and broken down by more recent craters. In fact, Catherina has a new ray crater within its walls! The new crater is inconspicuous near the terminator, but dominates its host at full.

Small marelike dark patches usually appear on the floors of older craters, especially craters that show definite signs of "wear and tear" — such as Alphonsus near the middle of the lunar disk, Plato near the north shore of Mare Imbrium, and the whole flock of craters just south of Mare Crisium. Their appearance in older craters, their marelike darkness, and of course high resolution orbital photos made in the last 1-1/2 decades show that these are areas where lava has flooded all or part of a crater floor. On the shores of Mare Foecunditatis, Mare Humorum and



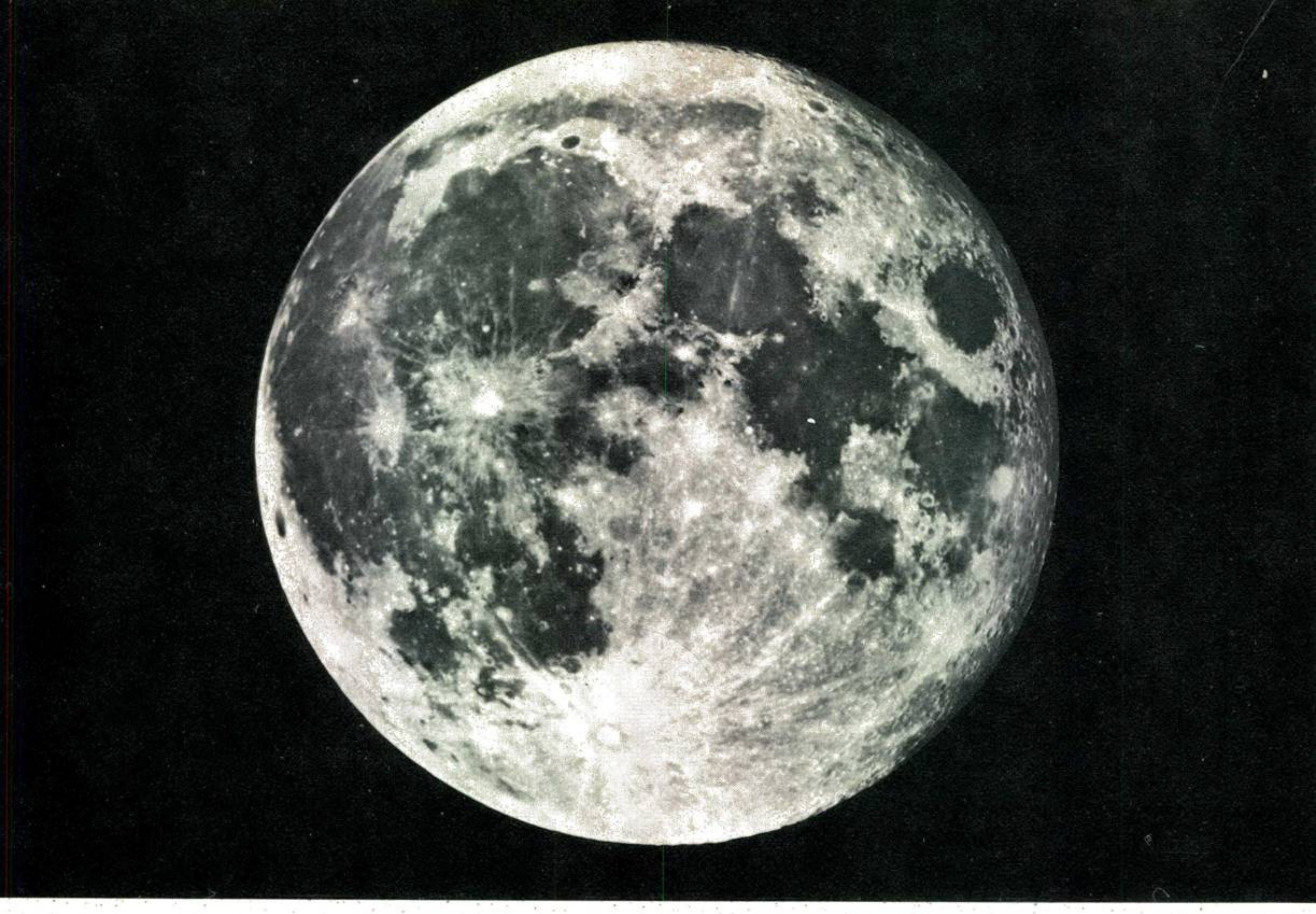


**Above: The crater Aristarchus and the Schröter Valley glow brilliantly on the terminator shortly before the moon reaches its full phase. The valley is one of the more puzzling features to be found on the lunar surface; there is no adequate explanation for its tortured, twisting shape. Opposite: Petavius, seen here shortly after full moon, is an older, slightly battered crater. A remarkable cleft crosses its floor to the central peak. Photographs by E. Ken Owen.**

Mare Frigoris, transition zones between an occasional isolated dark patch and continuous mare surface are laid out like a lesson in lunar geology that anyone with a telescope can see.

The maria really come into their own at full phase. At first glance into the telescope (or in a photo of the full moon), you notice that the maria are quite large and seem to be round. Photographs taken of the full moon are often printed to show the maria as black or very dark with vivid white highlands, but such photos don't accurately reflect the true appearance. The material of a mare surface reflects about half as much as the highlands (or bright) areas, so while the contrast is respectable, it isn't black and white. Mare Crisium is the "neatest mare" — almost perfectly round, sharply defined, and surrounded by a ring of bright mountains. The other circular maria are not so well defined; when their surfaces were covered with lava around 3-1/2 billion years ago, the impact basin must have been more ragged and irregular, or else lava overflowed the basins onto the cratered highlands. Lavas from Mare Foecunditatis, Mare Tranquillitatis, and Mare Serenitatis all seem to have flowed and spread across cratered areas. Along the north and east shores of Mare Tranquillitatis you'll see many half-flooded craters and hills. Also notice that there is hardly any mountainous rim at all! This is the darkest mare surface, as well as the smoothest; the latter condition influenced its selection as site of the first manned lunar landing. Mare Serenitatis stands in contrast: It is about half surrounded by cliffs and scarps, especially to the south near the bright crater Menelaus. A clear, visible dark band runs all the way around the edge of the mare, presumably reflecting the way lavas flooded the ancient premare basin.

Mare Nectaris is a small but significant "sea" It fills its own basin and has flooded the crater Fracastorius. But look a bit closer; to the south, Altai Scarp appears as a thin white line at full moon, and under careful inspection during many other phases, a ring of hills and cliffs runs nearly all the way around the mare at a more or less constant radius. It has been suggested that we are seeing a frozen shock wave in the lunar rocks, caused when the mare was formed by ancient asteroid impact. Mare Nectaris did not generate enough lava to fill to the second rim, but only flooded the inner basin. Mare Orientale, which we can't see from Earth, is a much more dramatic example of a mare surrounded by multiple



As little as one day after full phase, the ray systems on the moon's western limb decrease markedly in brilliance, as can be seen in the above photograph. A close comparison of this photo with those on pages 19 and 20 will show the change clearly. This high contrast view was obtained at the objective focus of a 10 inch f/6 home built reflector. The 1/60 second exposure was made through a yellow Wratten filter on High Contrast Copy film. Photograph by E. Ken Owen.

rings, and we can be sure that lunar geology would have developed differently if the obvious Orientale basin had been visible instead of Mare Nectaris' subtle clues.

Mare Imbrium may be the best studied part of the moon. It's huge, with a clearly circular shape defined by high walls: The Apennines and Caucasus mountains to the west, the Carpathians to the south and east, and the Alps and Juras to the north. Imbrium is almost certainly a lava filled impact basin — there's lots of evidence to support this, from detailed satellite photos down to simple visual evidence. You can see a circular outer ring of mountains, especially well outlined by the Mare Frigoris to the north, and in all directions are hills, faults and valleys pointing straight back at the mare and visible when the lighting is right.

On its surface, you can see faint brightness variations, suggesting the concentric outline of an interior basin that filled and overflowed, as Mare Nectaris did not.On the mare surface is the beautiful flooded crater Archimedes, fading near the time of full moon. Along the north shore is a line of mountains: Pico, Piton, the Teneriffes, and the Straight Range (Montes Recti).

To the south, Mare Nubium and Mare Humorum are poorly defined maria that have flooded or partially flooded the craters not only on their rims, but far "offshore" — suggesting rather shallow lava depths. Mare Humorum shows a well defined scarp along its eastern shore, but the rim is badly broken and flooded to the north and west.

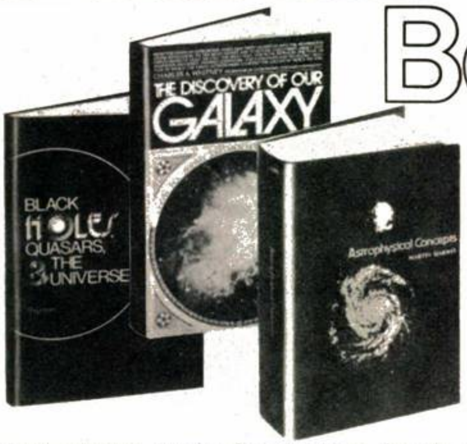
Oceanus Procellarum is a mare even though it is called "ocean." It extends more than 1,000 miles north-south, and has the largest area of any mare on the moon — though it looks fairly small because it's near the eastern limb and we see it at an angle. The western boundary of Oceanus is somewhat arbitrary since the mare lavas run right into one another. The Marius Hills region, a possible site of former volcanic activity, lies in mid-Oceanus. The far eastern shore of this mare area is invisible off the lunar limb some months, and well inside the limb in others due to lunar librations.

Although the full moon is sometimes considered the bane of the astronomer, it's worth taking a look at it when it's there. Even though you won't see the shadow-filled sharp relief of lunar hills and craters, there is still plenty to see in the subtle light and dark markings of the full moon.

**Man's assault on the mysteries of the universe... introducing astrophysics...radio astronomy...black holes... white dwarfs...neutron stars...Seyfert galaxies...**

sooner or later all the natural world reveals its secrets to members of the

# Natural Science Book Club



## Take any 3 books -values to $52.95- for only 99¢ each

**if you will join now for a trial period and agree to take 3 more books—at handsome discounts—over the next 12 months.**

Just about every fascinating facet of the natural world—past and present, earthbound to interstellar—comes under the scrutiny of the **Natural Science Book Club.** In books sure to delight the eye, quicken the pulse, expand the intellect, transport your mind to times past and times beyond, increase your enjoyment of astronomy through a deeper understanding of all man's worlds. You're but a postage stamp away from a host of adventures at welcome savings!

(Publishers' Prices shown)

**61915 MEDIUMS, MYSTICS AND THE OCCULT.** *Milbourne Christopher.* Down-to-earth examination of the occult by America's foremost illusionist. Highlights the feats of Uri Geller, ESP, faith healing, spirit rapping, and psychic surgery. **$6.95**

**36395. BLACK HOLES, QUASARS AND THE UNIVERSE.** *Henry L. Shipman.* Absorbing exploration of the frontiers of astronomy. **$12.95**

**57026. JOHN MUIR'S LONGEST WALK: John Earl, a Photographer, Traces His Journey to Florida.** Breathtakingly beautiful volume traces John Muir's 1867 walk from Louisville, Kentucky, to Cedar Key, Florida. Contains over 70 full-color photographs. *Counts as 2 of your 3 books.* **$30.00**

**34560. ASTROPHYSICAL CONCEPTS.** *Martin Harwit.* Challenging new presentation of the fundamentals of this important science, which bridges chemistry, physics, biology, mathematics, astronomy, meteorology, and the earth sciences. **$17.95**

**84285. TIDELINE.** *Ernest Braun.* Beautifully photographed and written—vividly depicting one day's change along the tideline. **$16.50**

**86300. THE WAY THE EARTH WORKS.** *Peter J. Wyllie.* Introduction to the new global geology and its revolutionary development. **$12.95**

**42325. THE DISCOVERY OF OUR GALAXY.** *Charles A. Whitney.* The lives and discoveries of great astronomers—from earliest observations to Seyfert galaxies. **$10.00**

**62630. THE MILKY WAY. Fourth Edition.** *Bart Bok and Priscilla Bok.* Thoroughly updated and expanded—the most popular book on our galaxy. **$15.00**

**45050. THE ENDS OF THE EARTH.** *Isaac Asimov.* Guided tour of the polar regions with the global relationships of sun, atmosphere and ocean . . . the present and prehistoric flora and fauna . . . and much more. **$15.00**

**57670. LANDMARK EXPERIMENTS IN TWENTIETH CENTURY PHYSICS.** *George L. Trigg.* Exciting account of almost two dozen of this century's greatest breakthroughs. **$18.50**

**34310. ARCHAEOLOGY BENEATH THE SEA.** *George F. Bass.* Exciting account of how the underwater exploration of a Syrian trading ship sunk in 1200 B.C. off the coast of Turkey paved the way for the science of underwater archaeology. **$12.50**

**54240. HUNTING FOR DINOSAURS.** *Zofia Kielan-Jaworowska.* The three-year effort to find and decipher the meaning of the ancient bones that litter the Gobi desert. Crammed with fascinating descriptions of dinosaurs and their evolution. **$12.00**

**49340. FUNDAMENTAL ASTRONOMY. Solar System and Beyond.** *Franklyn W. Cole.* Traces our intellectual assault on the mysteries of the universe from man's earliest sensory-oriented glimmerings to the very frontiers of modern astronomical thought. **$16.50**

**How the Club Operates** • The Book Club **News**, describing the coming Main Selection and Alternate Selections, will be sent to you 15 times a year at 3-4 week intervals. • If you wish to purchase the Main Selection, do nothing and it will be shipped to you automatically. • If you prefer one of the Alternates, or no book at all, simply indicate your decision on the reply form always enclosed with the **News** and mail it so that we receive it by the date specified. • The **News** is mailed in time to allow you at least 10 days to decide if you want the coming Main Selection. If, because of late mail delivery of the **News**, you should ever receive a Main Selection without having had the 10 day consideration period, that Selection may be returned at Club expense. • Continued membership past the trial period brings you the added benefits of our Bonus Book Plan—an important way to save even more, at least 70% off publishers' prices.

**46500. THE EVOLUTION OF RADIO ASTRONOMY.** *J.S. Hey.* ". . . an important work in the history of astronomy."—M.L. Meeks, in *Sky and Telescope.* **$10.00**

**85090. THE UNIVERSE.** *Lloyd Motz.* Its origin, evolution, and future. **$15.00**

**61610. MAYA. The Riddle and Rediscovery of a Lost Civilization.** *Charles Gallenkamp.* The incredible rise of Mayan civilization, its glory, its return to the jungle, its amazing rediscovery. A brilliant interpretation. **$12.95**

**41560. DANGEROUS TO MAN. The Definitive Story of Wildlife's Reputed Dangers.** *Roger A. Caras.* Cuts through the rash of fiction masquerading as fact to evaluate the relative dangers to man posed by animals ranging from killer whales to boa constrictors. Over 100 photographs. **$14.95**

**86125. WATCHING SEA BIRDS.** *Richard Perry.* Richly detailed, day-to-day account of colonies of breeding sea birds. Superb scientific reporting, filled with surprises. **$10.95**

**41705. DAUGHTER OF FIRE. A Portrait of Iceland.** *Katherine Scherman.* Deadly volcanic eruptions, 100% literacy, lowest infant mortality rate in the world—a fascinating island! **$12.50**

**77620. THE SECRET LIFE OF ANIMALS.** *Lorus and Margery Milne.* A mine of information coordinated with superb color photographs. *Counts as 2 of your 3 books.* **$29.95**

**IMPORTANT GUARANTEE!** Examine your 3 introductory books for 10 days. If not delighted, simply return them and your membership will be canceled. You pay nothing, owe nothing!

**Natural Science Book Club** 4-5AF
Riverside, New Jersey 08075

Please accept my application for membership and send me the three volumes indicated, billing me only 99¢ each. I agree to purchase at least three additional Selections or Alternates during the first 12 months I am a member, under the club plan described in this ad. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three books. A shipping and handling charge is added to all shipments. **Send no money. Members are billed when books arrive.**

**3 books for 99¢ each.**
**Indicate by number the 3 books you want.**

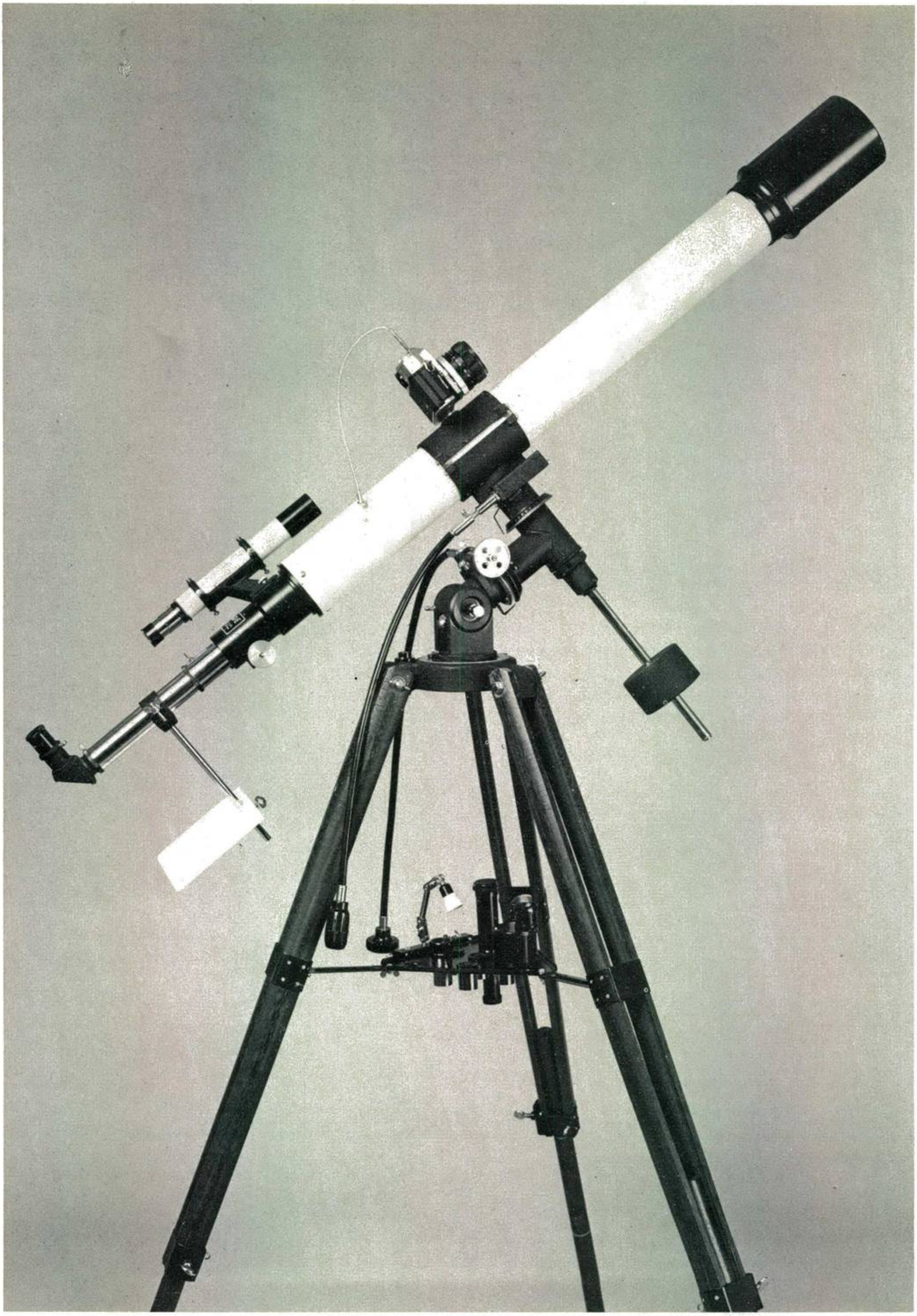
☐ ☐ ☐

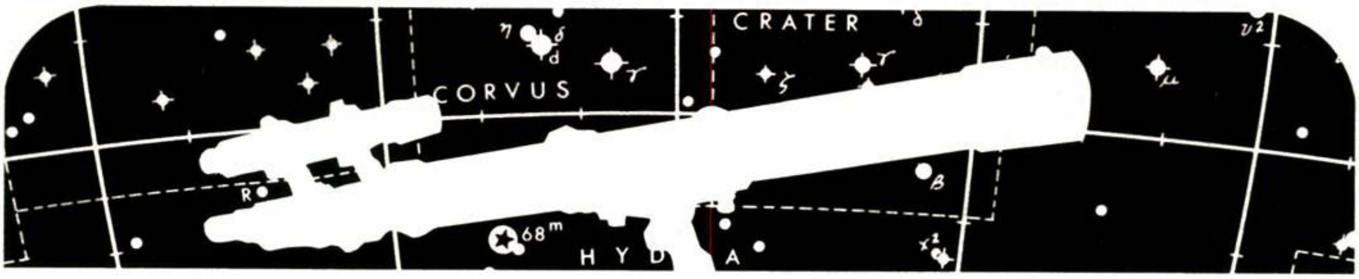
A few expensive books (noted in book descriptions) count as 2 choices.

Name ____________________

Address ____________________

City ________ State ________ Zip ________
(Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)





# What You Can See Through A Small Refractor

by

Henry J. Phillips

Nearly every owner of a small refracting telescope has had this experience: A friend invites you over to have a look at his brand new 10 or 12 inch reflector, and he proceeds to demonstrate the glory of the universe to you as you've never seen it before. After you return home, you gaze despondently at your small refractor, imagining your friend's contemptuous amusement, and you think, "I'll never be able to see anything through this opera glass!"

Sound familiar? There's no need for despair; far from being an opera glass, a 2.4 or 3 inch refractor is a valuable astronomical tool with certain advantages unmatched by other, larger instruments.

**The modern, sophisticated small refracting telescope is a valuable astronomical tool, useful for any type of observing. This 3.1 inch model is equipped with an equatorial mounting and slow motion controls — prerequisites for the type of piggyback photography demonstrated here. A solar viewing screen, Barlow lens, star diagonal, and several different eyepieces provide vast leeway in the amount and type of detail visible through this instrument. Meade Instruments photograph.**

Whether you're an absolute beginner or an experienced observer, the small refractor is an excellent telescope to use on almost any subject. And if you observe often through such an instrument, you'll eventually train your eye to catch more detail — something that will become extremely valuable whether or not you move on to a larger telescope.

Let's discuss the advantages inherent in the telescope itself. Almost all small refractors are easily portable — just right for that camping or fishing trip when you want something more powerful than binoculars, but can't squeeze a big reflector into the car. In addition, small refractors don't weigh very much, and they're easily set up and prepared for observing.

Many small refractors come equipped with an altazimuth rather than an equatorial mounting. This is unfortunate because, though it's true that the altazimuth is lighter and more portable, the equatorial mounting is preferable in almost every other way to the altazimuth. The most obvious advantage is the ability of the equatorial mount to keep an object within the field of view for a long time — a capability included in the actual design. If, however, you have a set of slow motion controls on an altazimuth mounting, it becomes fairly easy to keep the object you're studying within the field. Polar alignment is simpler with an equatorial mount, and a clock drive won't work with the altazimuth. If you decide you want an equatorial mount, it's a simple matter to attach your telescope tube to one.

The lens of a refractor, mounted at the top of the tube instead of deep inside it, is much easier to care for. Accumulated dust can be brushed away with a soft cloth or a camel's hair brush. It's a good idea to build or purchase a dewcap for the lens (if the telescope doesn't come equipped with one) to keep moisture from collecting on it. The water itself isn't harmful to the glass, but it may leave spots when it dries. And there's always the temptation to wipe the moisture away, which *can* scratch or damage the lens if you scour it often enough.

Once you've got your small refractor set up and ready for observing, what can you expect to see? Let's start with the two most obvious and brightest astronomical objects: the sun and the moon.

Several manufacturers will include a "sun filter" with a refractor — a small disk of thick, darkly tinted glass that screws directly into the eyepiece. *Don't use this!* The sun's rays will heat this glass so much that it can crack, exposing your eye to highly focused sunlight that acts as a large magnifying glass and can blind you in an instant. If you want to observe the sun, it's better to use a screen on which you can project the sun's image. With this method, you'll be able to notice large sunspots — and little else — on the solar surface.

Lunar observing is much easier and a lot more enjoyable. If you're just starting lunar observation, one of the best methods of learning your way around is to view the entire surface before you close in on details. A definite advantage of a small refractor comes in here: You can fit the moon's entire disk into one field of view at low power, thus enabling you to study the full face of the moon in its entirety. No other optical instrument has quite this capability; binoculars don't show enough detail, while larger telescopes yield the opposite problem in showing too much. Thus, it's easy for the beginner to get lost. A full disk view of the moon also permits you to grasp more completely the vast extent of such features as the maria and ray systems of craters like Tycho and Copernicus.

After you've begun to find your way around, the amount of detail you can see is enough to be satisfying — but not so much as to overwhelm and confuse the beginner. With a small refractor, you can discern features down to a few miles in diameter, and can easily observe the larger craters and mountain ranges. There is so much to see on the moon that you can spend a lifetime covering it mile by mile, and still find new details during every observing session. And, the moon is close enough that it permits this type of study. But what about things that are farther away — such as the planets?

All the planets except Pluto are accessible to the owner of a small refractor. Depending on how much power you want to use or is feasible under exisiting sky conditions, the amount of detail you'll be able to see will vary. No matter what power you use, though — even the lowest — the planets are always great fun to watch.

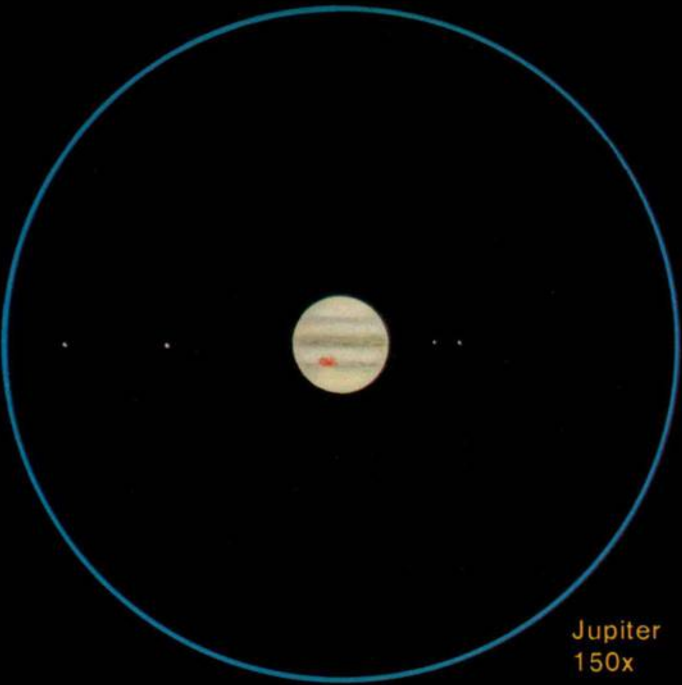
Mercury is the most difficult of the bright planets to see well, and visibility is always limited. You'll need at least a 100 power eyepiece to make out the phase, and even with a higher power, the phase is about all you'll see. Venus — being larger and brighter than Mercury — will have a more distinct phase. Here again, though, the phase is all you can expect to observe — not from any failing of your refractor, but merely because Venus' cloud surface prevents observation of *any* detail.

The three bright outer planets are much more interesting. Mars' intense red color is, of course, visible to the naked eye, and is easily seen through a small refractor. At opposition, you may be surprised at the amount of detail you can see. During the close opposition of 1971, Mars' polar caps and dark surface markings were readily visible — even at low power — through a 2.4 inch refractor. During those fleeting moments of excellent seeing, Mars can appear surprisingly detailed. Since we see the actual land surface of the planet (as opposed to cloudtops), Mars is a sight not to be missed under any circumstances.

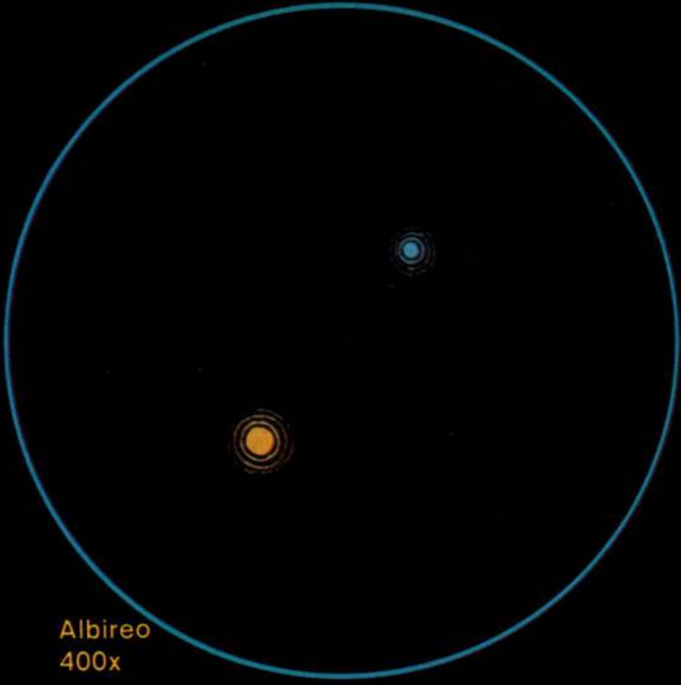
One of the most enjoyable pastimes for the owner of a small refractor is observation of Jupiter's satellites. All four moons are readily visible at low power, and all will fit in one field of view. You can watch the moons move back and forth from one side of the planet to another over a long period of time — or even during the course of a single night. At low power, Jupiter's glare is not great enough to be harsh. A special challenge facing the small telescope user is the attempt to see the satellites' shadows crossing Jupiter's disk. As for the planet itself, cloud bands and the Great Red Spot are obvious features. Observation of color and cloud detail requires more careful viewing and is excellent training for the eye.

The rings of Saturn are probably the first object the owner of a new telescope turns his instru-

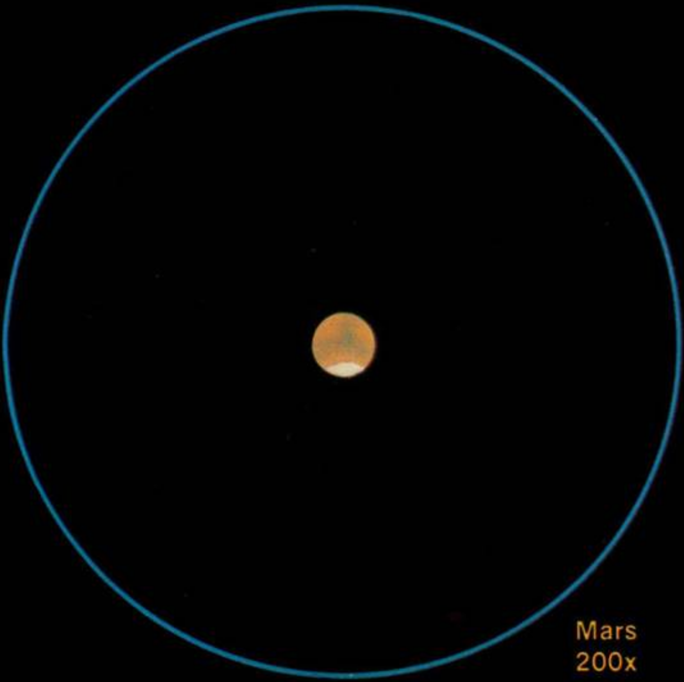
**Held at arm's length, the drawings at right show what you can see in a 2.4 to 3 inch aperture refractor while viewing with a right angle prism or "star diagonal". North is at the top, but the mirror effect a star diagonal creates flips east and west. Each object is shown as it would appear under the most ideal seeing conditions with *first rate, well-aligned optics*. Mars and Jupiter are both seen as they would appear at their best opposition. Artwork by Victor Costanzo.**



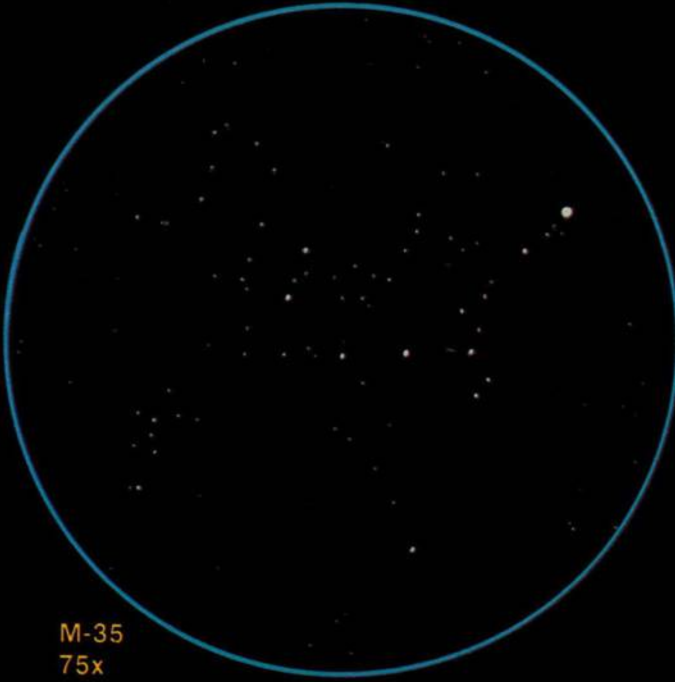
Jupiter
150x



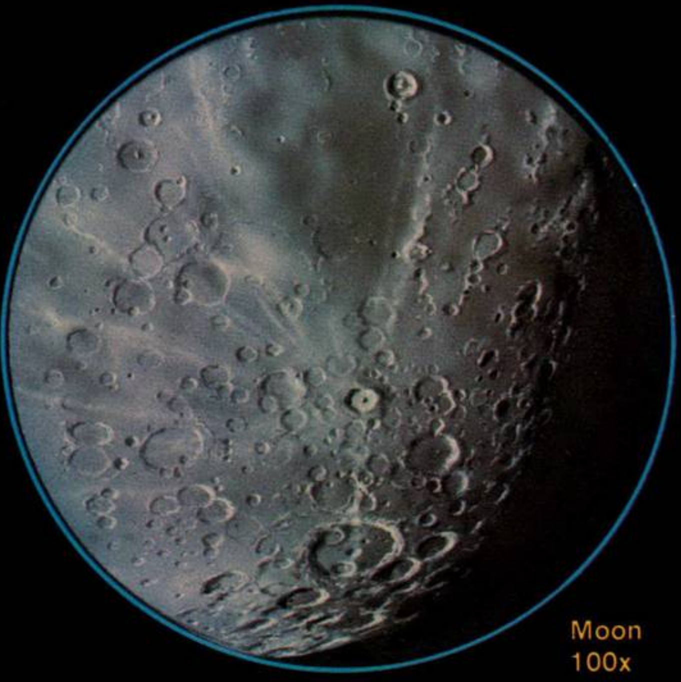
Albireo
400x



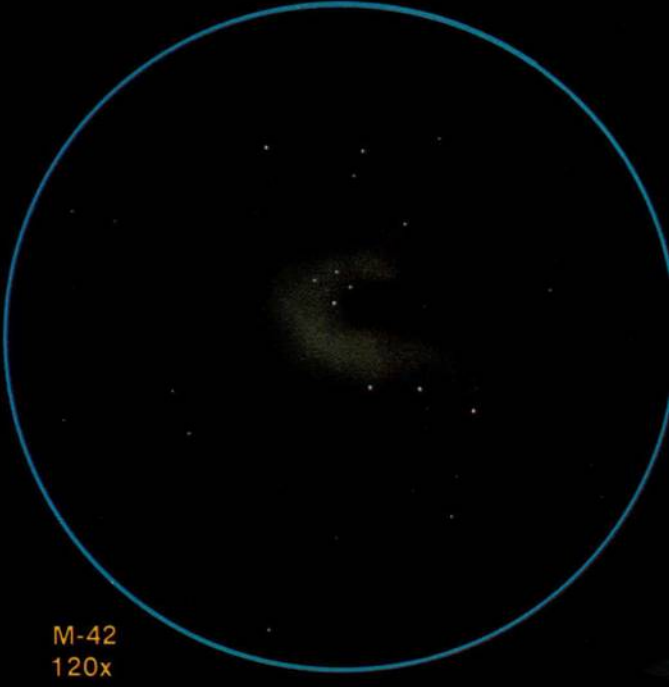
Mars
200x



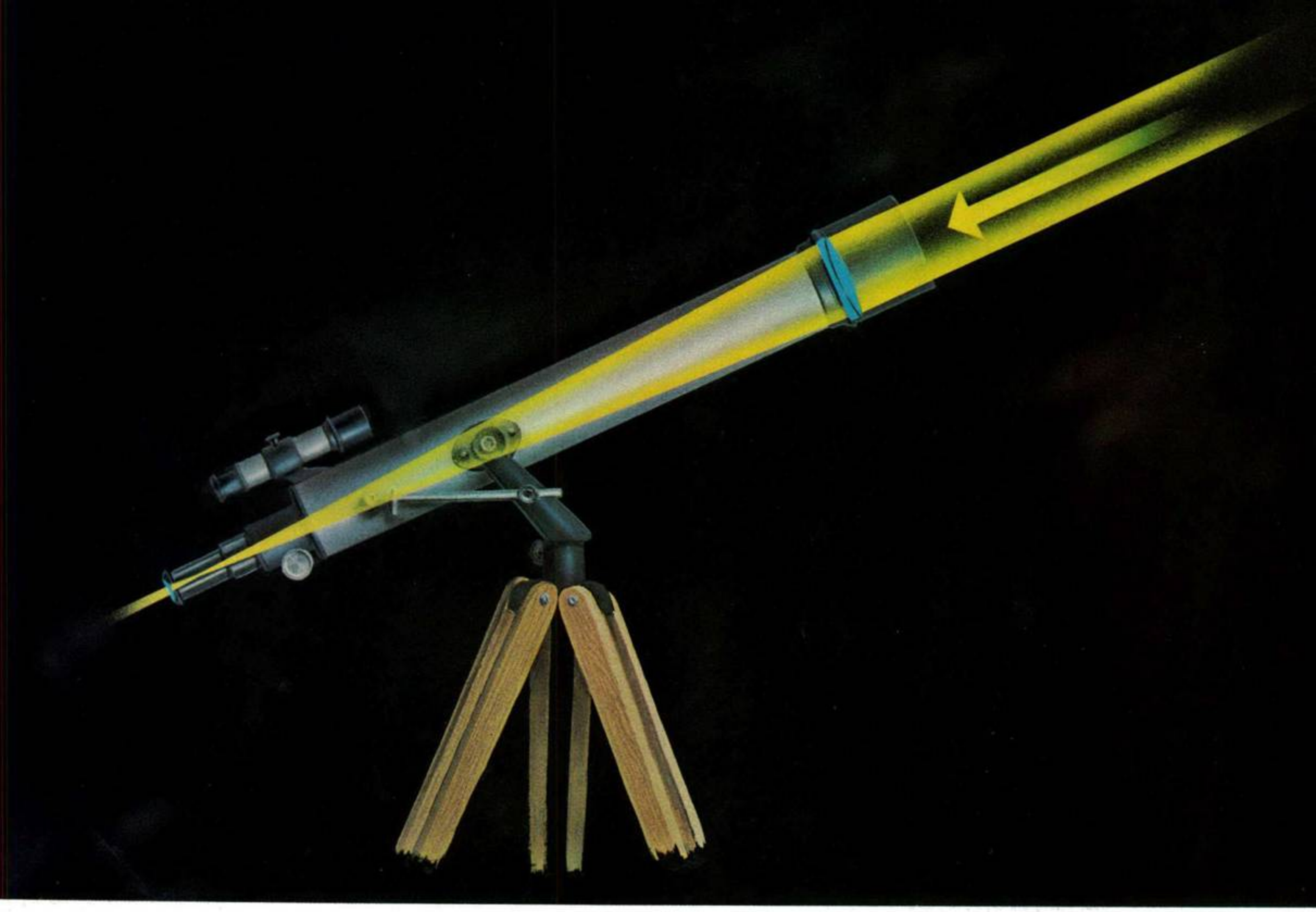
M-35
75x



Moon
100x



M-42
120x



ment upon (at least, if Saturn is in the sky). Under medium power with a small refractor, you can make out Cassini's division, as well as the variation in brightness within the rings. Surface detail on the planet itself will be limited to the brightest cloud bands. You should also be able to get a glimpse of several of Saturn's moons, although they aren't as obvious as those of Jupiter.

Don't neglect the other members of the solar system. You should be able to just barely make out the disk of Uranus through a small telescope and observe its bright green hue. Neptune can be seen as a blue-green star. The brightest asteroids are visible, and you can observe the changes in their positions from one week to the next during their oppositions. Finally, a small refractor is ideal for comet hunting.

Moving out of the solar system, the obvious next stopping point is the stars. The novice whose knowledge of the constellations is still rather shaky will find a small refractor a great help. Locating the individual stars that comprise a constellation figure is a big help in fixing the group in your mind, even if the stars are uninteresting in themselves. This exercise will also fill in your knowledge of the background stars before you attempt any deep sky observations.

Splitting double stars is a source of huge enjoyment for the owner of a small refractor, primarily because of the challenge involved in separating very close pairs. A good way to test the capabilities of your instrument is to find the minimum separation that your telescope can handle. You'll find that, as time goes on and you become more experienced, you'll be able to see more and more until you reach an absolute lower limit. Depending on the aperture your telescope has, minimum separation with a small refractor is about two seconds of arc.

**The optics of a small refractor couldn't be much simpler. The objective lens is mounted at one end of the tube and the eyepiece at the other end, so there's little reason to expect problems from faulty alignment. Light from a star enters the lens and is brought to a focus in front of the eyepiece, which acts like a magnifying loupe and also delivers a parallel light beam to the observer's eye. Artwork by Victor Costanzo.**

Observation of variable stars can be a valuable exercise. Follow one of the brighter, better known variables if you're just beginning (Algol is a good choice); it will add to your knowledge of stellar magnitudes and enable you to more accurately estimate the brightness of other objects. You can go on from there to studying variables whose minimum is almost at the lower magnitude limit of your refractor or even below, letting you discover the exact limits of your instrument. Watch some of the irregular variables too; you never know when some stars will flare up in brightness.

What about deep sky objects — nebulae, clusters and galaxies? This is where the small refractor owner most often feels discouraged. There's no need to be: Every one of the objects in Messier's catalog (and a good many that aren't) can be found with a small refractor. After all, Messier himself worked with such an instrument — his list was intended as a catalog of objects to avoid in his comet searching activities. In fact, the quality instruments available today are superior to Messier's telescopes, and it's a simple matter to identify all the Messier objects.

Open clusters are a fine sight through small refractors. Although such clusters as Coma Berenices and the Pleiades are too wide even for small telescopes, there are plenty of others to choose from — the double cluster in Perseus is an excellent example. Try looking at them under your lowest power initially; their condensed appearance in the center of a wide field can give a three-dimensional effect as the cluster sits against background stars. Increasing the power will, of course, increase the number of stars visible, and more and more components of a cluster will appear as you continue to observe. Globular clusters, being more condensed, are more difficult to resolve through a small refractor. You shouldn't have much trouble with the larger ones like M-13 or M-5, but smaller, more distant globulars will appear as a bright central core surrounded by a faint halo, with perhaps a little resolution around the edges.

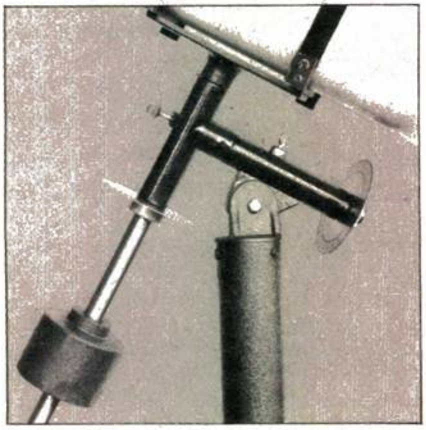
Nebulae are more difficult because they're more tenuous. Something like the Orion nebula (M-42) is, of course, readily visible even through binoculars, but you'll have more trouble with other fainter nebulae like the Crab (M-1) or Dumbbell (M-27). You shouldn't expect to see intricate structure; often a fuzzy spot is all that's visible. It must be admitted that most galaxies are also faint, fuzzy spots through a refractor (with the exception, of course, of large bright galaxies like M-31). But if you're just beginning, the mere identification of distant galaxies can be satisfying in itself once you realize what it is you're looking at (see "Observing Galaxies", ASTRONOMY, May 1976) — and it all helps to train your eye still further.

In any category — planets, stars or deep sky objects — it's best to start with the largest and brightest subjects and work your way down from there. One of the joys of owning a small refractor is that it allows you to do exactly this. If you do eventually go on to a larger instrument, you'll find that the experience you've gained from your small refractor is invaluable, and you'll want to keep it around for supplementary viewing. But even if a small refractor is the only telescope you'll own, there's still a wealth of observing open to you. All you have to do is look.

---

CONSIDER THE MOUNTING

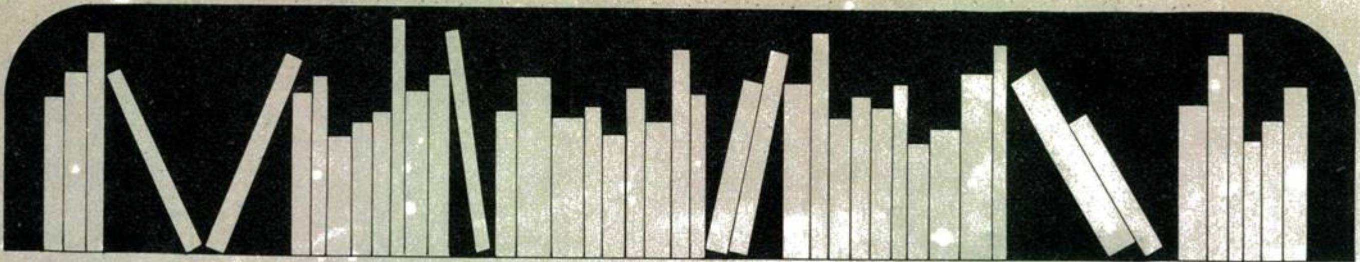
The Astronomer's Starter Package - 6 by S & S Optika represents the ideal "first scope" for the serious beginning astronomer. Consider, for example, the mounting:



A telescope must be a balance of three essential elements — portability, quality optics and mechanical stability. This 6" telescope has a mount with these important features found on **no other** in its price category: Long distances between bearing centers, precision lapped bronze bearings with **zero rumble,** precision ground 1" solid steel shafts and fully stress relieved aluminum castings. For further features see last months issue of Astronomy Magazine.

**S&S Optika, Ltd.**
**3853 S. Broadway**
**Englewood, Colorado 80110**

**Price f.o.b. Englewood, Colo. $187.50** (no crating charge)



ASTRONOMY REVIEWS

## The Amazing Universe

by HERBERT FRIEDMAN

199 pages (illus.), hardcover, $4.98
National Geographic Society (1975)

Here is a survey of astronomy for a lay audience that is an amazing bargain. Apparently the people at **National Geographic** have not heard about inflation, for they have produced a colorful, hardbound volume on modern astronomy that is both informative and beautiful for the price charged today for many unillustrated paperback books.

Herbert Friedman is a well-known physicist-astronomer, a pioneer in space astronomy and studies in the far ultraviolet and x-ray part of the spectrum, and a past chairman of the prestigeous Space Science Board of the National Academy of Sciences. In his text, he has undertaken to present a broad view of all of modern stellar astronomy, aimed at nontechnical readers who nevertheless have a little previous exposure to astronomy.

After two introductory chapters on history and the nature of astronomical research, Friedman moves through five chapters entitled: "Our Star the Sun"; "The Family of Stars"; "Stellar Beacons and Black Holes"; "Realms of the Galaxies", and "The Cosmic Order". The whole astronomical panorama is covered, with emphasis on the latest findings and most exciting problems of today — such as black holes, quasars, newly discovered sources of intense x-ray and infrared radiation, and the large scale evolution of the universe. The balance is good. The final short chapter, called "The Search for Life", is rather an anticlimax and could as well have been omitted. Only here is there any attempt to discuss planetary science, and the space allotted is clearly inadequate for the task. Perhaps **National Geographic** could be induced to produce a companion to the present book devoted to the exploration of our own solar system.

Any fan of ASTRONOMY is likely to be an equal fan of this book, for the two share much in their approach to astronomy — especially in illustrating the science with photographs and drawings that are at the same time technically accurate and pleasing to the senses. More than 60 percent of **The Amazing Universe** is pictorial, mostly in color. Strikingly drawn diagrams — many using the new "false color" techniques for emphasizing subtle features — and lovely photographs of star fields and nebulae from Hale and Kitt Peak Observatories are supplemented by five fine paintings by Adolf Schaller (one of ASTRONOMY's contributing artists). Other illustrations and their captions provide a running history of astronomy and an international gallery of 20th century scientists. Particularly impressive are the photos (many by James P. Blair) of astronomers in their working environments, taken in the superwide-angle style familiar to readers of **National Geographic** . Observatories are not forgotten either, with pictures of Kitt Peak, Cerro Tololo, and Hale Observatories, and of the great radio telescopes at Green Bank, Arecibo, Bonn and Westerbork. The highly informative captions can be read independently of the text and make this a pleasant book for casual browsing as well as more serious reading.

The **Amazing Universe** is the product of teamwork by a group of illustrators, editors, producers and staff writers, as well as by Friedman. It includes an introduction by Phillip Morrison, a good glossary, a detailed index, and a list of titles for suggested further reading. In addition to its many other virtues, this book is remarkably up-to-date, containing references, for instance, to the cracking in September 1975 of the 127 inch mirror for the NASA infrared telescope in Hawaii and the discovery at about the same time of Snickers, the new dwarf companion to our galaxy.

How many other publishers could turn out a 200 page, handsome, lavishly illustrated, technically accurate book containing information only three months old and sell it for only $4.98? *David Morrison.*

*The editors of ASTRONOMY highly recommend this excellent reference book to its readers.*

◆

## The Outer Solar System (two volumes)

edited by JURIS VAGNERS*

## Exobiology

edited by MARTIN FREUNDLICH and BERNARD WAGNER**

## Astronomy From a Space Platform

edited by GEORGE MORGANTHALER and HOWARD GREYBER***

One of the most important aspects of the advancement of science is found in a peculiar institution: the scientific conference. Hundreds or thousands of scientists gather from around the world to report on their latest research, discuss new developments, and plan coordinated programs of exploration and investigation. They exchange speculations and new ideas. These conferences are the most crucial part of the communication which helps scientists work together and advance.

Occasionally these conferences are mentioned by the news media when a particularly spectacular discovery is announced, or an abnormally bitter debate is raging. But the vast majority of reports which the conferees hear and discuss are never reported by the press.

The solution to this problem is called the "conference proceedings" — which is opening a new avenue of information. All presented papers are compiled (often with the text of discussions following each presented paper) and published by the sponsor of the conference for sale to conferees, interested scientists who could not attend and interested outsiders.

These three books have been selected for review despite their age, since they can be considered classics of the past decade. Like most conference proceedings, their limited printings have resulted in higher than normal prices. But the density of solid information more than compensates for the costs.

Five years ago, planetary scientists were contemplating the unique opportunity offered by an alignment of the outer planets in the late 1970s. Utilizing a "planetary swingby" mode, an unmanned spacecraft would be able to zoom by Jupiter, Saturn, Uranus and Neptune — one after the other — within a 10 year period, because of the energy picked up in each swingby. (A direct flight to Neptune would normally take more than 20 years.) The lineup would not re-occur for centuries, and space specialists urged NASA to plan such a "grand tour" mission. Congress, however, would have to allocate the money.

Scientists met in Seattle in June 1971 to discuss new spacecraft systems needed and what was already known about the targets of the new spacecraft. They also concentrated on listing the unknowns — the mysteries of the outer solar system which the grand tour might be able to solve. Sixty papers were read in ten special sessions. Most of those papers (written before the two Pioneers reached Jupiter) are still important today even though the grand tour was never approved, and even though the Pioneer 10 and 11 probes rewrote the book on Jupiter. (Half of the grand tour — Mariner-Jupiter-Saturn — will be launched in 1977, and the probes may even reach Uranus.)

Six papers discuss general strategies and surveys of outer solar system exploration. Particularly interesting are reports of "Pioneer-class Mission Capabilities" (new Pioneer missions are being planned for the late 1970s), and an assessment of comet and asteroid mission possibilities. The natural environment session then discussed all that was known about the outer planets before 1971; much of that data is still valid.

Less pertinent are the next sessions on projected technology (some of it outdated) and nagivation and guidance problems. (This is a fascinating, little known, but fairly technical problem: How do you steer a spacecraft so accurately, so far from the sun and Earth, and by remote control?)

The last major section of the first volume, however, is as important today as when it was printed, and is especially relevant to astronomy. It discusses plans for scientific experiments and instruments for general missions beyond the asteroid belt. What should these probes measure, and how? How can telemetry data be translated into scientific discoveries?

The second volume of the **Outer Solar System** deals mostly with engineering problems and mission planning. The mission analysis and design section was not dependent on specific flight hardware, so it is still timely today. The same is true for the session on Jovian planet entry probes, which are nearly as far into the future today as they were in 1971. Problems of specific component integration are probably still valid but of little interest to the general reader; the latter objection also applies to the section on the problems of long-lived space systems which must endure more than a decade of harsh space conditions without failing.

An unexpected and delightful closing session on flights "beyond the solar system" redeems this volume's few drawbacks with imaginative visions of the first steps beyond the solar system, ultraplanetary probes, and the exploration of new stellar systems. In effect, each excellent section in the volume is probably worth the whole price — and there are many excellent sections.

What was not realized five years ago was the exciting possibility that parts of the outer solar system — particularly Jupiter and Titan — might be likely homes for organic molecules or even life. This oversight is the primary weakness of the late 1960s conference on exobiology, "the science without (prior to Viking) a subject". But **Exobiology** is still one of the most detailed reports of a remarkable field which has had far too few books written about it.

Well-known space scientists Carl Sagan and Wolf Vishniac (who later was tragically killed in Antarctica while testing his life detection instruments) discuss their views on exobiology. Other specialists talk about techniques for detecting life beyond Earth (many have been incorporated in Viking), techniques of interstellar communication, and the origin of life on Earth and elsewhere. A freewheeling discussion fills much of the last part of the book, with almost every aspect of life in the universe (including UFOs) covered at length.

The last book, **Astronomy From a Space Platform**, is a reward for the patient reader: very full of information, very difficult for casual examination, and probably the most important generally available book on the topic to appear in the past decade. It is a challenge — and a "must" — for any astronomer or serious enthusiast interested in the revolutionary new capabilities of space based astronomy.

Objectives and instrumentation for planetary, solar, stellar and galactic astronomy are each detailed in papers still relevant today. The only outdated section outlines Skylab solar astronomy experiments (and even these can still be of interest as a model for future large space observatories).

The importance of space for astronomy lies not just in the new wavelengths which are opened up for investigation; the resolution in visible wavelengths also improves dramatically. "The structure (of the sun) is... almost overwhelmingly intricate, and many fundamental processes occur over dimensions smaller than we can currently observe." Such potential benefits from space astronomy are exhaustively catalogued.

New astronomy disciplines (such as high energy, x-ray and particle astronomy) are detailed, along with the very large space telescopes and advanced instruments of the future. Papers describe long baseline interferometry, synthetic aperture optics, electronic imaging, automation techniques and "active" optics. Strategies of utilization of these powerful tools close the book.

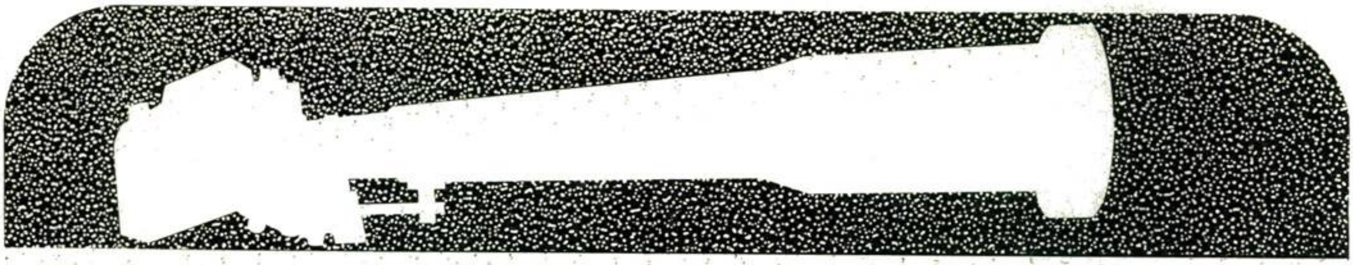
The main problem with conference proceedings lies with the varying quality and differing technical levels of the presentations. Some papers are simple surveys, while others are extremely detailed examinations of specific problems.

An unintentionally humorous example of this latter situation can be found in an engineering article which is explaining a new piece of equipment: "For the nonspecialist, think of a Michelson Stellar Interferometer." Clearly, the author was not speaking to a genuine nonspecialist audience; a lot of background knowledge was assumed.

There are valuable sections in all of these books, but unfortunately their prices put them out of the range of most individuals, making them more appropriate for school libraries. The last one is the best, and real space astronomy enthusiasts should have their own copies, since it lays the foundation for the next 20 years in space astronomy. Readers should expect a challenge, but the rewards are there.
*James E. Oberg.*

**Published in 1971. Volume 1: 1,601 pages, hardcover, $30.00; volume 2: 2,724 pages, hardcover, $30.00. **Published in 1969; 172 pages, hardcover, $15.00. ***Published in 1972; 398 pages, hardcover, $25.00.*

*Each is available from the American Astronautical Society, P.O. Box 746, Tarzana, CA 91356.*



# Photograph the Milky Way

by
Hal R. Jandorf

In late summer and early autumn the Milky Way is at its brightest, stretching from the southern horizon to nearly overhead in a cloudlike band of stars. While your eye can only discern the Milky Way's overall nebulous glow, photographic emulsions can record hundreds of faint stars, galactic clusters and glowing nebulae. All you need is a clear dark country sky and a bit of simple equipment to get rewarding photographs of the Milky Way. Once you've captured the faint objects within it, you can take the time to study them when clear skies are unavailable — or when you return to the city, where pollution hides the Milky Way's wonders.

Almost any camera-telescope combination is useful for Milky Way photography. Any camera with a lens faster than f/3.5 can do excellent work, and any equatorial mount with a clock drive or manual slow motion controls is sufficient to get exciting results.

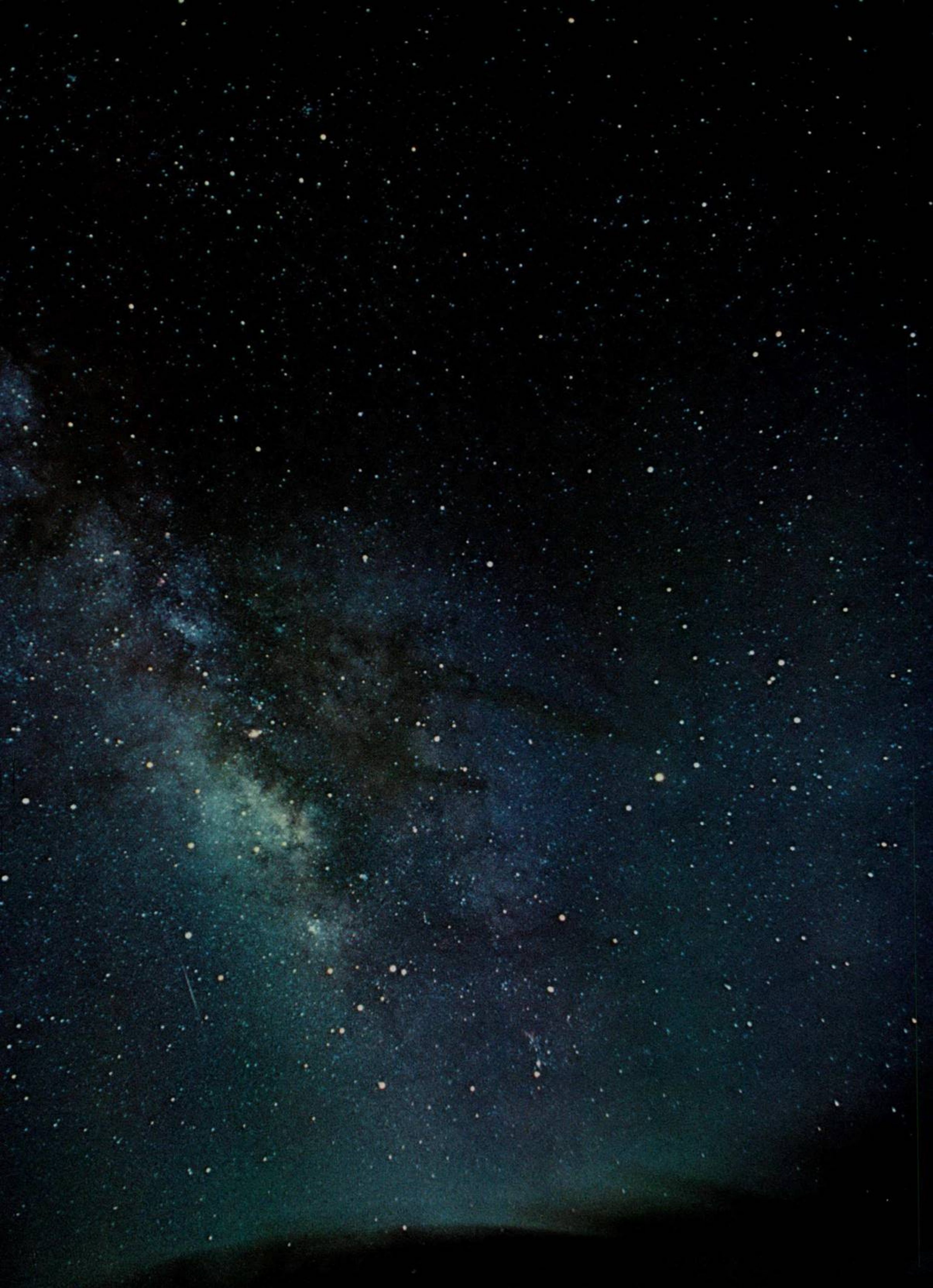
The Milky Way is a wide field object, and you can therefore cover more of the subject with a wide-angle lens. Superwide-angle fisheye lenses show 180 degrees, but because of fisheyes' minute image scale, only the major structures of the Milky Way can be photographed. Ordinary wide-angle lenses with focal lengths of 24 to 35mm show large scale distribution of starlight and dark nebulae, along with locations of interesting details in context. Telephoto lenses isolate the details (such as individual nebulae), but the restricted angle of view makes coverage of a large area of sky a lengthy and somewhat tedious task.

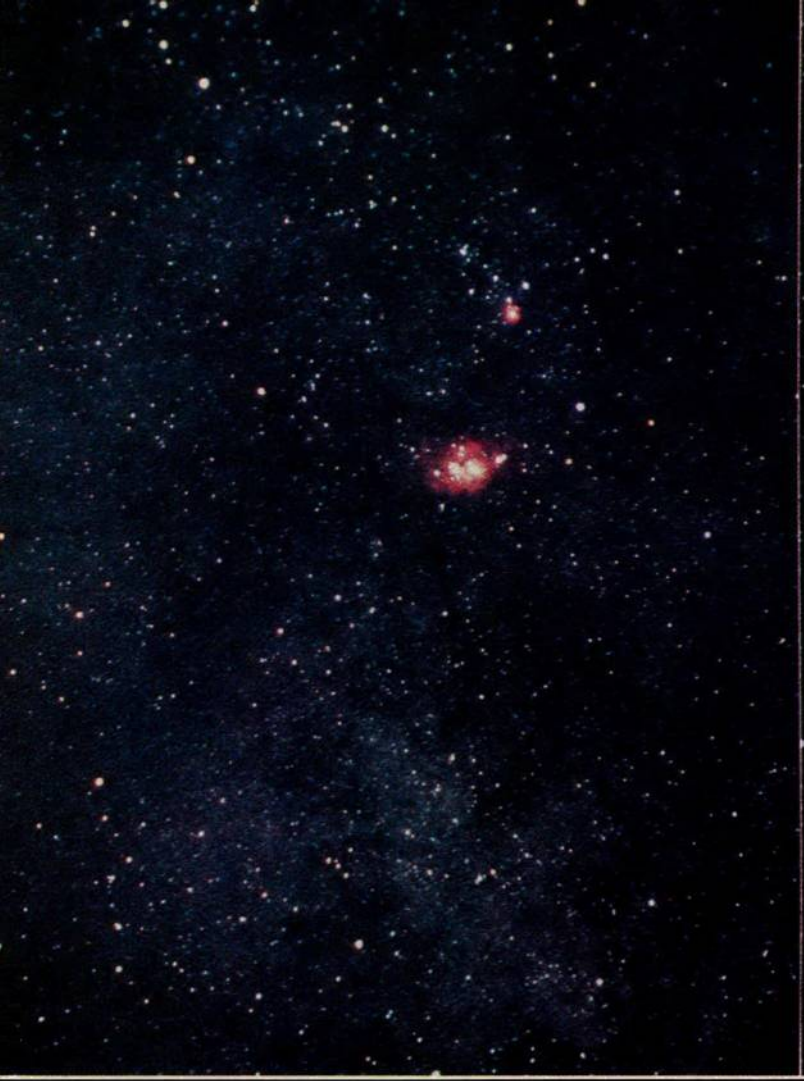
So you need not be surprised that the normal lens found on almost any good camera offers excellent field coverage, and still provides enough detail to make it a good compromise between wide-angle and telephoto lenses. A 50 or 75mm lens has a wide enough field to "forgive" all but major guiding errors. A good photograph is almost guaranteed if you keep a star centered on the crosshairs of a 100 power eyepiece, while the camera is attached piggyback to the guiding telescope. It can be that simple!

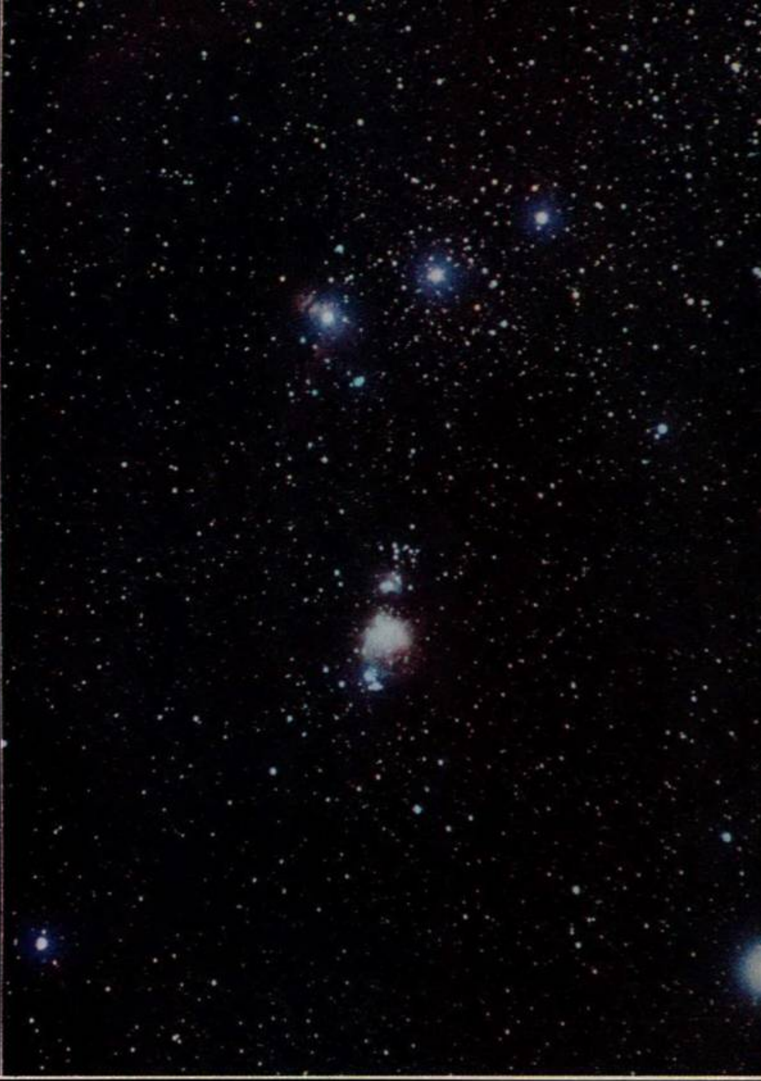
### Lens Quality and Films

Milky Way photography depends greatly on lens quality and speed. At a wide open aperture, some of today's fast lenses distort star images at the edges of the photographic field, while others at the same price level give excellent star images. By taking several experimental exposures at progressively smaller f/stops, you'll find out how far you should stop down for satisfying images all the way to the edge of the photograph. But a lens that has faster speed or aperture will require a shorter time for the exposure. Thus the best lens will give sharp star images throughout the photograph at the fastest f/stops. You can't tell in advance how good a lens will be; trial star pictures are a must. If you can get good images at f/2.8, you're "in". Even cameras not usually considered "serious" can give satisfactory results at f/2.8.

**The rising summer Milky Way shines in all its glory in this wide-angle shot taken from the mountains of California. A 24mm lens was used, stopped down to f/5.6 for this one hour exposure on GAF 200 film. The broad outlines of the star clouds are emphasized, while small detail is lost. The clear atmosphere at this site allowed recording of the star clouds and cluster right to the horizon. Photograph by Brad Wallis.**







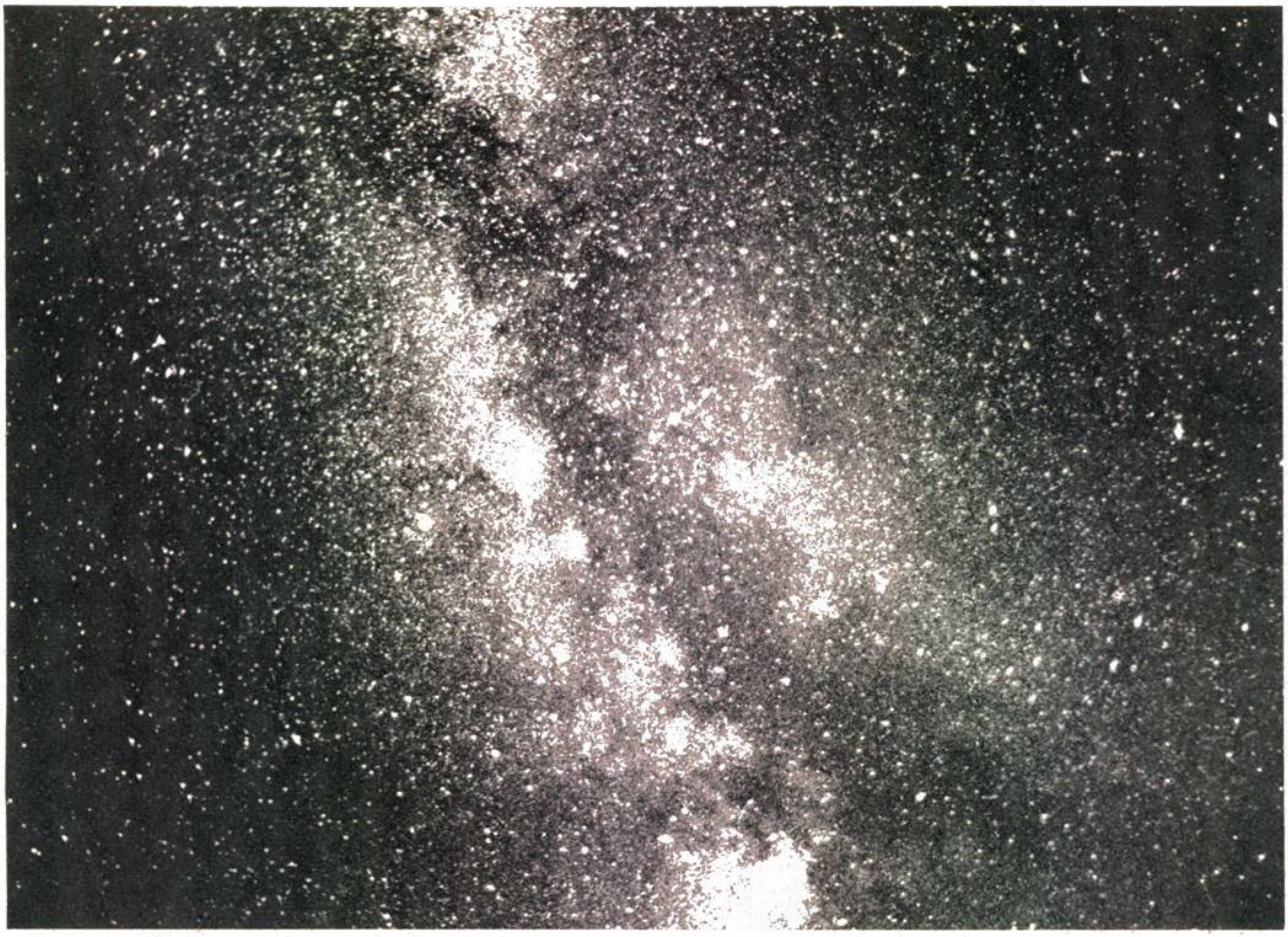
Opposite upper: The star clouds of Sagittarius are plainly visible just above the "spout of the teapot", while the Lagoon nebula is near the top center. Opposite lower: In a 15 minute exposure, dust lanes in Scorpio, the globular cluster M-4, open clusters M-6 and M-7 are captured vividly against the dark California sky. Both photos on GAF 500 were made using a 55mm f/1.7 lens. Photographs by Hal Jandorf. Above left: With a longer focus lens, more detail is visible in the Lagoon and Trifid nebulae. GAF 500 was exposed for eight minutes with a 135mm Lentar lens. Photograph by Lawrence Carlino. Above right: Orion, located in the winter Milky Way, is filled with nebulosity in this 25 minute exposure on GAF 500 taken with a 135mm f/1.8 telephoto lens. Photograph by Byron Labadie.

Choice of film is crucial to the Milky Way photographer. Whatever high speed film has the most appeal for the individual astrophotographer will generally determine film choice. For color film, GAF 500, GAF 200, High Speed Ektachrome and Fujichrome R-100 are the most common choices. Each film yields differing sky background colors. The GAF films give an appealing blue-green effect; High Speed Ektachrome will have a neutral brown background, and Fuji R-100 force-processed gives a reddish background. Poor quality commercial processing can cause strong false background colors, so you'll have to either shoot all your slides on one roll of film or (if you use more than one) turn them all in for processing at the same time — unless you want wide variation in the sky background you record!

Photographing the Milky Way on black and white film should be handled in the same manner as color slides. Since black and white film is usually more sensitive than color film, it may have a tendency to pick up lens errors that do not show up on the color emulsion. Try stopping the lens down one or two f-numbers to obtain better images. The increased sensitivity of black and white film (such as Tri-X) allows shorter exposure times. Exposures can range from five minutes to a half hour depending on lens aperture, film speed, or the amount of stars and nebulosity you want the film to record.

The special black and white emulsions (103aF and 103aE), made for astronomers by Kodak, provide great opportunities to penetrate deep into the faint recesses of the Milky Way. These special red-sensitive films are optimum for faint objects and long exposures. The films have very high contrast and are far less affected by the decrease in sensitivity in faint light (called reciprocity law failure) that commercial emulsions suffer from. Used with a red filter (Wratten #29, Schott RG-630 or RG-645) to eliminate sky fog, 103aE is very selective in recording the gas clouds in the Milky Way (see "A Red Window to the Sky", ASTRONOMY, February 1975).

If you print your own black and white films, you'll have more control over the final picture; this makes black and white preferable in some ways to



**Opposite, above: High Speed Ektachrome pushed to ASA 400 was used to capture the Sagittarius region in this 19 minute exposure with a 55mm f/1.8 lens. Compare the color rendition and graininess to the pictures on GAF 500 on page 37. Photograph by Robin Foster. Opposite, lower: A 135mm lens at f/2.5 captured the North American nebula in a 30 minute exposure on Kodak 103aF film with a #25 red filter. The original photo was black and white; color was added later by ASTRONOMY. Photograph by Leo C. Henzl Jr. Above: A wide-angle lens and Tri-X film captured the Milky Way stretching from Scutum into Cygnus. The 20 minute exposure was made through a 28mm lens at f/2.5.**

color in obtaining the exact picture you want. Details that are nearly invisible on slides stand out strongly on black and white prints if you use a very high contrast paper.

### Guiding

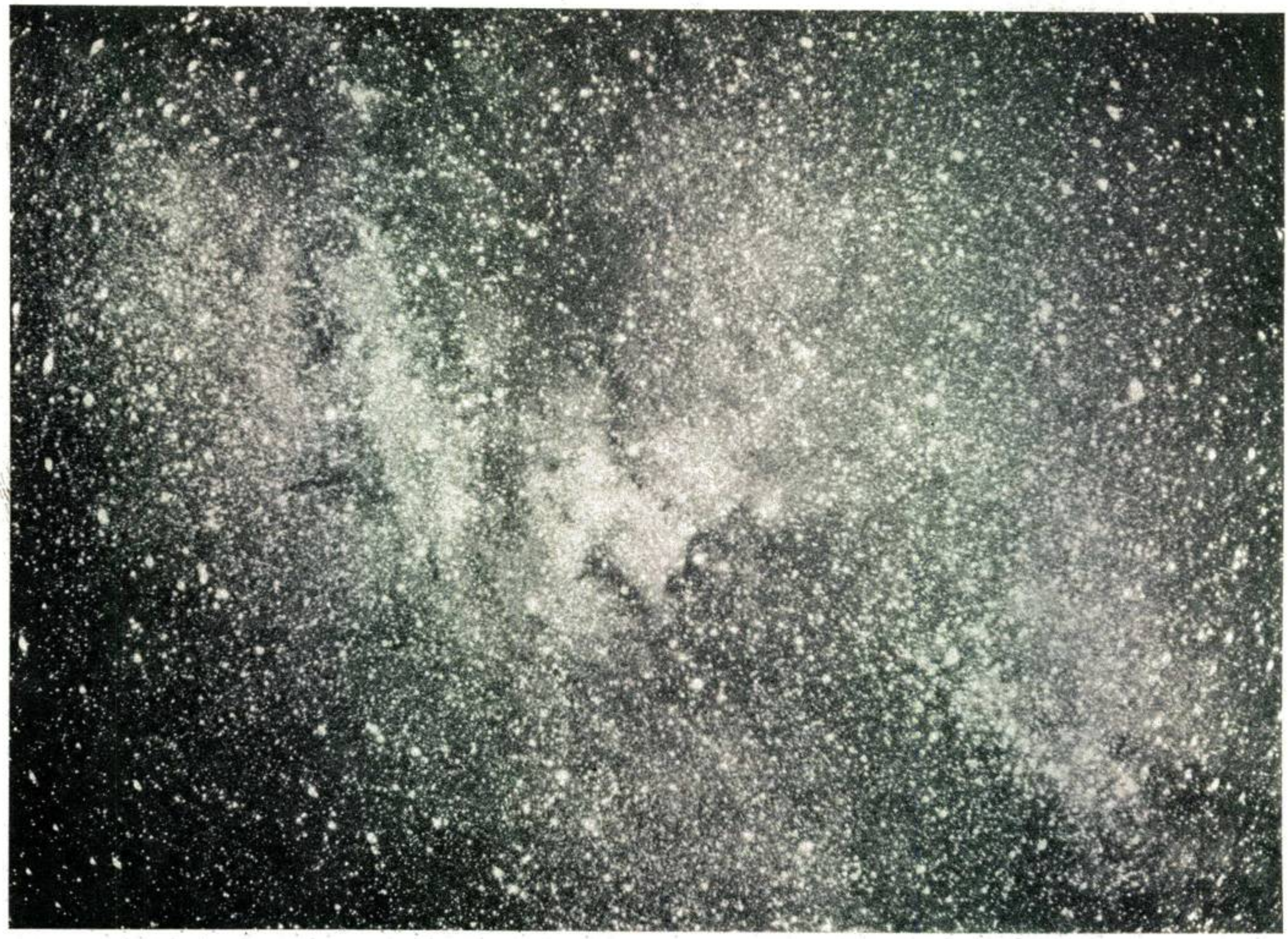
Guiding is easy. With a 50mm lens, you can allow the stars to trail for 10 seconds without harming your shot, and with wider angle lenses (such as 28mm) that time is nearly doubled. All you have to do is piggyback your camera on a telescope with an equatorial mount, keeping a star image centered in a high power eyepiece during your exposure. The mount must be fairly well aligned on the pole or the stars will trail in circles around your guide star. If possible, use a crosshair eyepiece; it will be easier to guide and you can use a much lower power (25 power is sufficient with a 50mm lens). If you have a good clock drive, chances are you won't even have to make a single correction in a 10 minute exposure.

You can get a quick idea how much error is tolerable in your magnified field of view by letting the star image drift off the crosshairs for 10 seconds. That amount will just barely show a trail with a 50mm lens. If you can keep your image centered by that amount or better, your images will be little short of perfect.

Illuminated crosshairs are easier to see, especially when you have the dark sky necessary for this kind of photography. Illuminated crosshair eyepieces can be purchased by mail order from several firms (including Roger W. Tuthill, Inc., Meade Instruments, Edmund Scientific Co.).

If you're inventive, you can make your own by mounting two thin wires, or hairs, at the focal plane of an eyepiece. Locate the focal plane by moving a pin inside the barrel of the eyepiece until the tip of the pin is in focus: This will be the location of the crosshairs. A source of illumination can be a wheat grain bulb or light emitting diode (available at electronics stores), mounted in a hole drilled in the eyepiece barrel. A power source can be penlight batteries hooked up in a series with a rheostat for controlling light intensity.

As mentioned before, a 50mm lens allows some guiding errors without ruining the photograph. Possible errors include turning a slow motion knob the wrong way; turning the wrong slow motion knob;



From the dark skies of Craig Leith Park in Ontario, a five minute hand guided exposure on Tri-X using a 50mm f/2 lens reveals the brilliant sweep of the Milky Way in Cygnus near Deneb. The North American nebula is nearly lost against a dense background of stars. This photo is one of a series covering a large fraction of the Milky Way visible from the northern hemisphere. Photograph by William Morrow.

bumping the telescope mount with a stray foot, or the eyepiece with a clumsy head.

All these errors may result in losing the guide star temporarily, but a short focal length lens (50mm) allows time to recover the guide star and save the photograph. Have a lens cover ready in case some extraneous source, such as car headlights or an airplane, enters your picture. Once the light moves away, the camera lens can be uncovered and guiding resumed.

### Milky Way Panoramas

One way to get around the limited angle your lens can cover — in other words, if it isn't wide enough to show the overall Milky Way — is to piece together several pictures taken with long focus lenses. In a panoramic picture you get excellent detail, lost by wide-angle lenses, as well as a full scale view of the Milky Way.

The most difficult part is matching the prints that you stick together for your panorama. Most lenses give a dimmer image toward the edge of the frame, and your panorama will look uneven if you try to place your pictures end-to-end. Use a fairly generous overlap so you never have to use the edges of your frames; alternately, you can stop down an f/stop or two while shooting to obtain more uniform results. You'll have to plan the contents of each shot ahead of time for a good looking result. To obtain the proper overlap, write out a "shooting schedule" so you'll know which stars should be in the field of the camera.

Uniform background color and tone is a must for a panoramic view. If you print color from slides or negatives for your panorama, print the photographs all at once so that the chemicals, exposures and print scale are the same. This will help you avoid mismatching prints.

You can attach the final prints to a backing of heavy illustration board, using print cement or adhesive mounting tissue. Don't use rubber cement — it turns pictures yellow in a few years. Trim your photo with an extremely sharp knife; and, of course, get plenty of practice joining and mounting prints before you start on your final panoramic view.

When you have taken your pictures — whether they are black and white or color, prints or slides — you will want to spend a few cloudy nights carefully inspecting them. Search out the hundreds of clusters and nebulae, the dark clouds and the rich star fields — those objects that the eye of the camera records so well — all components of the galaxy we live in.

## PLANNING TO MOVE?

Let us know **8 weeks in advance** so that you won't miss a single issue of **ASTRONOMY**. Attach old label where indicated and print new address in space provided. Also include your mailing label whenever you write concerning your subscription. This way, you can help us serve you promptly.

**Write to:** ASTRONOMY Circulation Services, P.O. Box 186 Westchester, IL 60153

If you have no label handy, print OLD address here.

Name

Address

City

State Zip

Print NEW address here.

Name

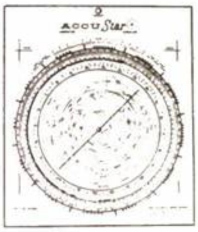
Address

City

State Zip

---

## ACCU Star



**SIDEREAL TIME**
ANYPLACE — INSTANTLY — ACCURATELY

- Whether you are a begining or advanced astronomer, to find any object in the sky, you must convert your local time to sidereal time units.
- Accustar does it quickly without paper and pencil. Accustar teaches you how to use your telescope's setting circles. Accustar is used by observatories, universities, and astronomers throughout the world.
- Each Accustar package contains: The basic Accustar instrument with star chart, Sky Finder overlay, and the Accustar 90 page text. Order yours today! $11.95 ppd.

### OBSERVATION BINOCULARS

These are some of the finest large aperture binoculars we have ever seen! 20 power with 80mm. objectives. American type frames. Erfle eyepieces. Over 17 inches long. Built - in sliding tripod adapter. Fully coated lenses with luggage type carrying case with lock.

20x80 BLCF ______ $232.00 ppd.

### NEW BINOCULARS FOR DEEP SKY OBSERVATION

We are now carrying a number of large binoculars of special interest to astronomers. All models have fully coated optics , center focus design, and come complete with a nice quality carrying case. The 11 power model has a 4.5 degree field and the 10 power model a 5 degree field. These models represent the ultimate in rich-field viewing.

8x56 RCF ______ $ 99.95 ppd.
10x70 ZCF ______ $110.00 ppd.
11x80 ZCF ______ $129.00 ppd.
20x80 ZCF ______ $129.00 ppd.

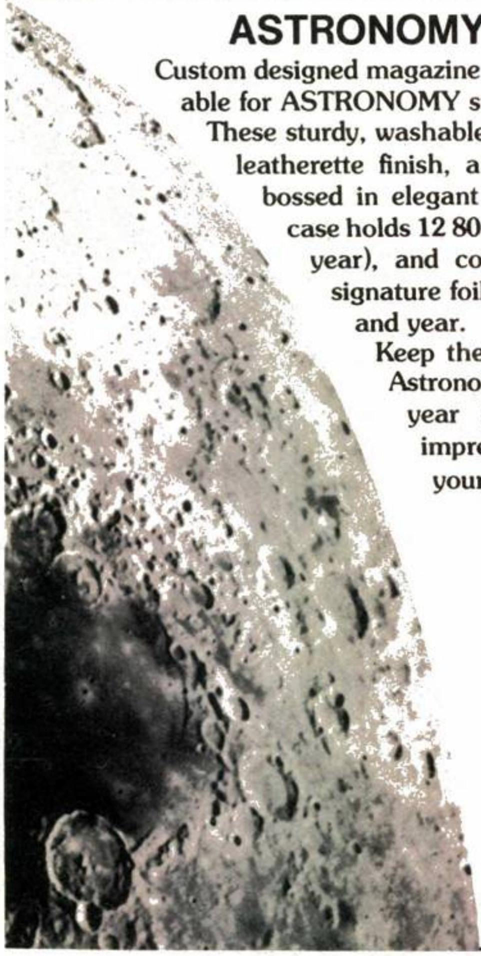
**GET FREE CATALOG NOW**

Send for our complete catalogue of telescope parts, eyepieces, mirror kits, finders, focusing mounts, books, and accessories. It is yours for the asking.

"AN OLD AND EXPERIENCED SUPPLIER TO THE TELESCOPE FIELD"

**University Optics, Inc.** 2122 East Delhi Road Ann Arbor, Mich. 48106 free catalog

---



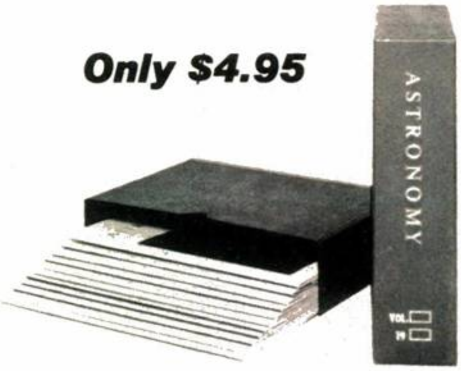
## ASTRONOMY Volume Files

Custom designed magazine Volume Files are now available for ASTRONOMY subscribers.

These sturdy, washable cases have a rich brown leatherette finish, and ASTRONOMY is embossed in elegant gold on the spine. Each case holds 12 80-page issues (one complete year), and comes with a slip of gold signature foil to fill in volume number and year.

Keep the World's Most Beautiful Astronomy Magazine beautiful year after year with this impressive addition to your library.

***Only $4.95***



*$4.95 each or 3 for $14.00, 6 for $24.00*

To order, simply fill in and mail the attached coupon today!

Use this address **ONLY** for Volume File orders and correspondence regarding them.

ASTRONOMY Volume Files
P. O. Box 5120
Philadelphia, PA 19141

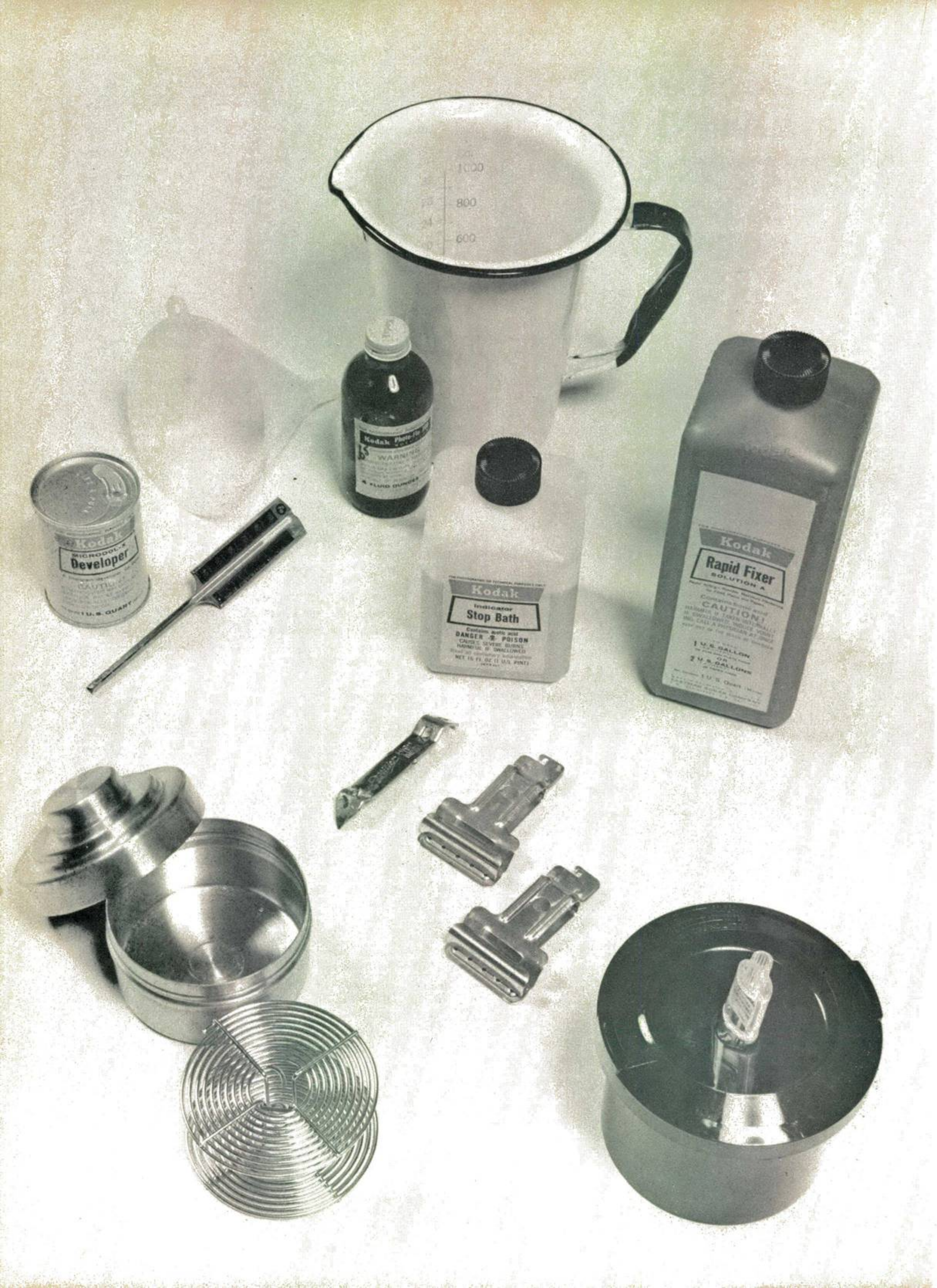
Enclosed is $ ______ in payment for the following
ASTRONOMY Volume Files:
______ 1 for $4.95 ______ 3 for $14.00 ______ 6 for $24.00

Name ______

Address ______

City ______ State ______ Zip ______

U.S.A. orders only. Allow 3 weeks for delivery. Full money back guarantee.


1000
800
600
Kodak Photo-Flo
WARNING
4 FLUID OUNCES
Kodak
MICRODOL-X
Developer
CAUTION
1 U.S. QUART
Kodak
Indicator
Stop Bath
Contains acetic acid
DANGER POISON
CAUSES SEVERE BURNS
HARMFUL IF SWALLOWED
NET 16 FL OZ (1 U.S. PINT)
Kodak
Rapid Fixer
SOLUTION A
CAUTION!
1 U.S. GALLON
OR
2½ U.S. GALLONS

# Setting Up An Astrodarkroom

by
Richard Berry

The thrill of making your own pictures is only part of the reward you can derive from setting up your own darkroom and doing your own developing and printing of pictures; you can get the quality that commercial processors offer, as well as greater control over your final results. A darkroom need not be a major investment, and need not take very much space nor create a mess or smell around your home.

The two basic darkroom operations — developing film and making enlargements — can be undertaken separately since they require very little overlapping equipment. You can start by developing your own film and having it commercially printed, and then later (if the do-it-yourself bug bites you) — for a very small added expense — you can try making contact prints. Finally, for about $100 more, you can plunge into enlarging with the purchase of an enlarger.

In this article, we'll discuss the space, types of equipment, and capital you'll require to start your own astrodarkroom. Then, in the next few months, ASTRONOMY will bring you specific "how tos" about developing film and enlarging your own negatives. Of course, many other articles are available on amateur photography in monthly photo magazines and the numerous books available in bookstores and libraries. We'll try to offer some extra hints that will especially help the *astro*photographer, including darkroom tricks that ordinary photographers often don't use.

**Shown here is the basic equipment needed to process films. It includes: a stainless steel film tank (lower left); an inexpensive plastic film tank (lower right); chemicals — dry or concentrated, as they come from the store; a funnel, thermometer and mixing graduate (upper left); can opener and film hanging clips (shown between the developing tanks), and "Photo-Flo" solution — film is rinsed in this diluted solution before drying. Not shown are quart bottles of dilute chemicals.**

Where can you put a darkroom? The first thing to realize is that the equipment is pretty compact and doesn't have to be out except when you are using it, so anyplace you can find four to six feet of counter or table space that you can darken (absolutely essential) will do as a part-time darkroom. It will be far more convenient if it is close to a sink and drain, which will probably narrow your choice to the kitchen, bathroom, or a basement laundry room. When you aren't using it, your darkroom equipment can be stored neatly out of sight. If you work at night, simple dark curtains or black plastic can darken the room adequately; if you want to have a daytime darkroom, you'll have to set close-fitting, light-tight wooden frames covered with opaque plastic over the windows. You'll need water to mix chemicals and, of course, spills are easier to clean if they happen in a sink. Running water is necessary to wash your developed film and prints. You can do the developing and enlarging in a room without faucets, but it is less convenient and there is always the possibility of spilling chemicals while carrying trays or bottles back and forth.

Where your darkroom is, then, depends mainly on your specific requirements and availability of space, darkness and water. In general, bathrooms are best, with the space over a bathtub being a prime candidate. You'll need to install a drop-in table made of plywood, and waterproofed with paint or wax to act as a work table over the tub. The prints can be dropped into a few inches of water in the bathtub

## Equipment for Your Astrodarkroom

For a beginner, purchasing photographic equipment can be a fearsome chore because you probably aren't sure what exactly you want or need. You do know you want to get the best without paying too much. Camera salesmen can be helpful, but of course they want you to spend lots of money. There's plenty of good quality equipment on the market — solid, durable, well designed and reasonably priced. Your local camera store may not always have the equipment you need if they cater primarily to the snapshooter, but you can safely order by mail from firms that advertise in most photography magazines because they keep as close a watch on advertisers as does ASTRONOMY. The table below and continued on the opposite page will help you decide what you need and approximately how much it will cost.

### B&W Film Processing

| Item | *Need | Cost | Comments |
|---|---|---|---|
| Developing tank | Y | \$6-\$10 | Stainless steel, look for tight fitting top; if plastic, precision molding, smooth mating surfaces, freedom from shop damage. |
| Developing reels | Y | \$3-\$5 | Sold with plastic tanks, separate purchase with stainless steel. Look for accurate assembly, proper reel spacing, clip in center. Buy same brand as tank. |
| Graduate | Y | \$3 | Look for easy to read numbers, pouring spout. |
| Thermometer | Y | \$1-\$4 | To ±1/ 2° F. accuracy; numbers should read easily. |
| Funnel | Y | \$1 | Buy at grocery or hardware store, plastic or metal. |
| Phototimer | N | \$3-\$40 | Watch with sweep second hand works just as well, but a good timer should run at least 60 minutes. |
| Chemical Bottles | Y | ±\$1 | Juice bottles fine for quart; cider, soda fountain jugs for gallon. Plastic bottles available at camera stores are very expensive. |
| Film Clips | Y | @50¢ | Plastic clothespins work too, and cost less. |
| Can Opener | Y | 50¢ | Best way to open film cassettes. |
| Changing Bag | O | \$6-\$10 | Needed if you can't darken closet or bathroom; lets you load developing tank in daytime; handy on trips when away from darkroom. |
| Developer | Y | \$1 | Per Quart: Kodak D-76, Kodak HC-110, Ilford D-11 for normal negatives. |
| Stop Bath | Y | \$2 | Per Pint: Kodak Indicator Stop Bath. |
| Fixer | Y | 80¢ | Per Quart: Kodak Fixer F-5, Kodak rapid fixer. |

after each is processed. In the kitchen, counter space near the sink or a nearby table usually works best, with prints going into a big plastic tub of water for washing after processing is completed. The basement offers minimum interference from other people, the best prospects for daytime darkening, and usually more space to work in. You may have to try several places before you find the ideal spot.

Film processing requires less space, but you do need total darkness to load your film into a processing tank. Either a closet or a film changing bag made of opaque cloth will fill this need. Once your film is in the lightproof tank, you can work neatly in or beside any sink with the lights on, and film can be washed in any sink. You'll want a dust-free place to hang the film to dry after washing it; again, the bathroom is usually ideal.

What equipment do you need to process film and make enlargements? The table above lists your basic needs, as well as more elaborate equipment for those who wish to invest the money. You can do perfectly well without some items, such as film clips. But even a beginner should have the best of certain other items, such as a good developing tank.

How do all these bits of equipment fit into the overall scheme of doing your own astrophotography? To make it clear, we'll quickly go over the entire process from taking the film out of your camera to holding the final 8 x 10 enlargements in your hands. You'll see it isn't very tricky, and if you work carefully and neatly, you virtually can't go wrong.

The initial step in developing film is preparation of the chemicals. But first, a few words about the chemicals themselves: They are not poisonous unless you drink large quantities; they are not dangerously acidic or alkaline. If spilled, things can get very messy, so lay newspapers down and keep a large sponge handy for quick clean-ups. Avoid prolonged contact with your skin, as you may be allergic to them.

There are three necessary chemicals: the developer, which makes the image appear; a stop bath, which neutralizes the developer, and the fixer, which renders the developed film insensitive to light. One set of chemicals will last for about a dozen rolls of film, so you won't have to prepare your solutions very often. Simply measure a quantity of water in a mixing graduate; add a packet of dry chemical powder; stir it until it's dissolved, and pour the solution

## B&W Print Processing

| Item | *Need | Cost | Comments |
|---|---|---|---|
| Print Trays | Y | @$3 | Need three. Look for a deep tray to minimize sloshing. Ridged bottom helps agitation during processing. Buy larger than the paper size you'll use; for 8x10 prints buy 11x14 trays. |
| Print Tongs | O | @$1 | Must be able to grip wet paper without damaging delicate surface. Handles must have ridge to prevent slipping into tray during processing. Buy the best. |
| Safelight | Y | $10-$15 | Look for solid construction, well attached cord, stand or mounting brackets. Inexpensive models that screw into light sockets are generally poor. |
| Timer | O | $3-$40 | Controls enlarger exposure; necessary to get consistently exposed prints from same negative. Beginners use watch sweephand. |
| Contact Frame | Y | $15 | Makes contact printing easy, but can be replaced with regular window glass. |
| Developer/ Chemistry | Y | $2 | Kodak Dektol developer (one gallon) different than for film. Stop bath and fixer are the same as for film processing. |
| Enlarging Paper | Y | $4 | For 25 sheet package, Cut 8x10s into smaller pieces for small prints. To get started buy "Single Weight Glossy Grade F3". |

## Print Enlarging, Washing, Drying

| Item | *Need | Cost | Comments |
|---|---|---|---|
| Enlarger | Y | $70-$120 | Condenser enlarger for astronegatives. Solid stand, head easy to move up and down, good finish on metal film gate where film must insert and remove easily, smooth focus. You may want 2-1/4 x 2-1/4 to 4 x 5 film capacity even though you only do 35mm now. |
| Easel | N | $15 | Holds paper during exposure, makes white border. Tape does the job less expensively. |
| Focuser | O | $10 | Need for accurate focus on grain of negative for sharpest astrophotos. |
| Wash Tub/ Print Washer | Y | $3<br>$30-$60 | Plastic dish pan is good for washing 10 to 15 8x10s at once with running water. Print washers are good if you do many prints, but they may not do an adequate washing job. |
| Electric Dryer | O | $30-$60 | Beware: There are many poor quality print dryers on the market. If you do, buy with thermostatic control and cloth cover that can be removed to clean. |
| Squeegee & Screen Rack | O | $5 | To air dry prints. Contamination free, and easy to build yourself. |

*Need: Y = Yes N = No O = Optional

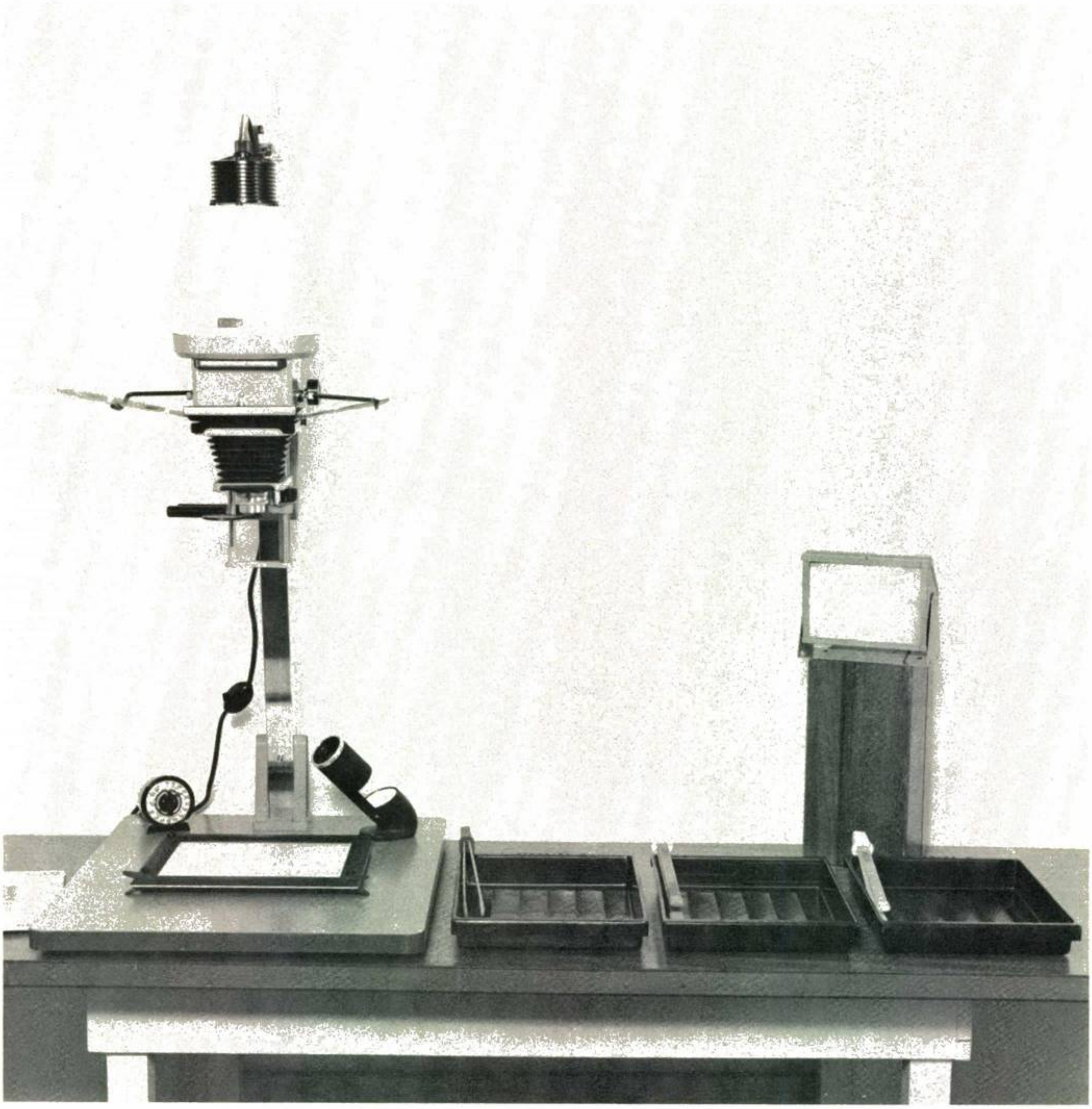
into a storage bottle. Now you're ready to proceed.

In your selected area, set the film tank, film reel, a can opener and the roll of film in front of you. With the lights off, pop open the film can, using the opener, and remove the film. Wind it on the film reel (since reels vary, there is no general advice for this procedure) which will hold it in a spiral so the chemicals can reach every bit of it; then put the reel into the light-tight film tank, and turn the lights back on. (If you don't have a suitably dark room, you can perform the loading operation with your arms and hands inside a film changing bag made of black cloth.)

Carry the tank to a sink. Measure the temperature of the developer with a standard thermometer and look up the proper developing time — usually between 5 and 10 minutes — in the directions that come with the film. Pour the developer into the film tank, and note the time on a watch or clock or turn on your phototimer. Give the solution a shake or stir every 30 seconds until the developing time is up, and using a funnel, pour the developer back into the bottle. Pour the stop bath into the tank for a minute, and then back into its bottle. Finally, pour in the fixer for the recommended time (usually 5 to 10 minutes). Take the lid off the film tank and let a stream of cool tapwater flow over the film for 1/2 hour to wash out any residual chemicals in the emulsion. Using plastic clothespins or film clips, hang the film up to dry in a clean, dry, dust-free place. Your film is now developed!

Enlarging requires somewhat more elaborate preparations, so we'll just review the basic operation. Your enlarger is like a precision slide projector that projects an image of the negative onto a sheet of photographic paper — that is, paper which has been coated with a photographic emulsion sensitive to blue light. Beside it on the table or counter are three shallow trays containing about a quart of the developer, stop bath and fixer previously mentioned. A safelight (a low-wattage light bulb covered by a yellow or orange filter) hangs overhead. Since photo paper is only sensitive to blue, you'll be able to see, but the paper will be safe from exposure.

To start, remove a sheet of photographic paper from its box or paper safe. Place it under the enlarger on an enlarging easel or hold it lightly with double sided masking tape. Turn on the enlarger, timing your exposure. After exposing, place the photographic paper in the developing tray and rock it



Enlargements can be made at home with a setup comparable to this one. At left, the enlarger projects an image of the negative onto a sheet of photographic paper which is held in the enlarger easel on the baseboard. At right, paper is developed, stopped, and fixed in solutions contained in the three trays; adequate working light is supplied by the yellow safelight. (The print washing tub and print drying equipment are not shown.) Many good enlargers are available for around $100.

gently to get uniform chemical action over the surface. Since some people are allergic to developers, you should develop the habit of using tongs or an oversized rubber glove if necessary to handle the paper when it's in the chemical solutions. After a few moments your picture will start to appear on the page; you'll be able to see it darken and develop under the safelight. After two minutes, it will be fully developed; transfer the sheet into the stop bath to halt the development, and then into the fixer for 5 to 10 minutes. After fixing, you can turn on the room lights and inspect your results. While you make others, the prints can go into holding in a big plastic tub of water, the bathtub or whatever is convenient. Most papers have to be washed in running water for about an hour to remove all chemical traces from the emulsion.

The finished — but wet — prints can be dried in an electrically heated print drier, or can be squeegeed semidry and placed on inexpensive racks made of fiberglass window screens to air dry naturally.

With that, you'll have done it — your own enlargements from your own negatives at a quality level that will compete with the best commercial processing as you gain experience. You should be able to top drugstore processing right away!

Photograph by Nile Root. Unitron 4" telescope on an Equatorial mount.
Taken with a Nikon F camera.

# Travel through Unitron to the far reaches of space.

When you do, you'll enter an exciting new world of awesome beauty. As you scan the heavens, your Unitron will reveal the panorama with breathtaking sharpness and clarity.

And there's a Unitron telescope that's right for you. Whether you're just entering the fascinating field of astronomy, or whether you need a more sophisticated instrument than the one you are using.

Whatever Unitron model you choose, you can be sure you've selected the finest—in value and quality. A precision instrument with superb optics that will give you pleasure for years and years.

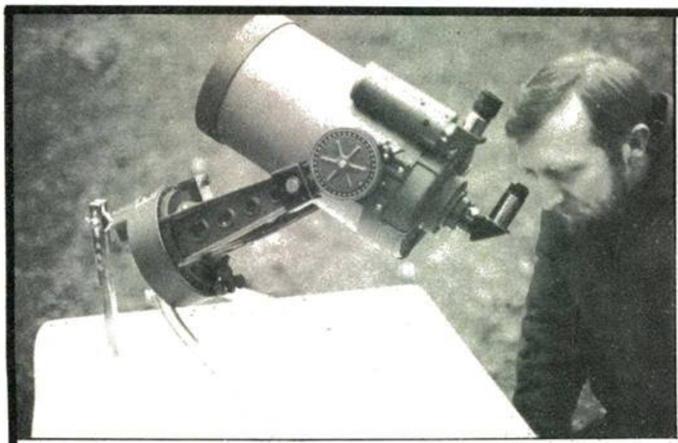
Come travel through space with us. Write for our illustrated brochure today, and select the instrument you'll be proud to own.

Unitron Instruments, Inc., 101 Crossways Park West, Woodbury, N.Y. 11797

*UNITRON* **The value line.**

**Immediate delivery on most models.**

Unitron Instruments, Inc.
Sub. of Ehrenreich Photo-Optical Industries, Inc.



***BUY YOUR NEW***

**CELESTRON® 5 OR 8**
**TELESCOPE**

***from TUTHILL***
***Stock Delivery***
***FREE ADVICE***

**PRESENT CELESTRON OWNERS:** Would you like to have increased protection from dewing — make lining up on the celestial pole a snap without leveling your tripod or knowing your latitude — look at the zenith easily with a large finder — adjust the tripod height for sitting or standing — increase the fine adjustment of the right-ascension knob — see the setting circles with built-in lights — have a five pound sturdy portable equatorial mount which duplicates the wedge and tripod function but which stores in the box — motorize your manual declination adjustment — increase your declination circle resolution five times — have a helical focuser — carry your valuable scope securely with a sturdy retractable handle?
**WRITE TODAY** for more information on our unique items that will enhance your pleasure in using these beautiful world-renowned instruments. We stock all the standard CELESTRON accessories, too.

## NEW: STAR-TRAP™ ELECTRONIC EYEBALL™

Be an armchair astrophotographer. Don't waste your time with your eye glued to a guiding eyepiece during your astrophotographic sessions. Let our NEW solid-state eyepiece unit issue the necessary right-ascension guiding commands to your present right-ascension drive corrector while you relax in comfort indoors watching TV or reading about astronomy. Manual guiding is obsolete! The STAR-TRAP ELECTRONIC EYEBALL™ will work with most standard drive correctors. Write today giving the specifications on your present drive corrector.

For those who do not have this valuable photographic accessory we offer a STAR-TRAP DRIVE CORRECTOR of unparalleled accuracy, stability, and reliability. All solid-state; works from 117 volts AC or 12 volts DC. Write today for more information.

***ASK FOR DETAILS OF OUR OFFER OF A FREE SOLAR-SKREEN AND CELL FOR YOUR SCOPE.***

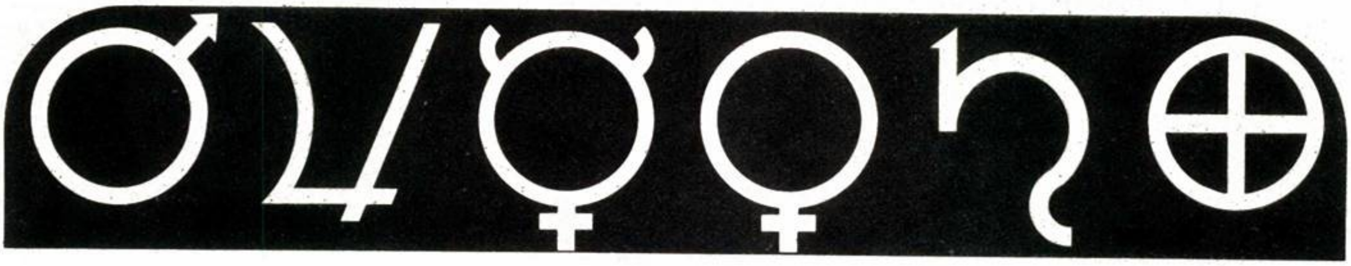
**SEND FOR OUR NEW FREE CATALOG** which will help you enjoy more fully your exciting hobby. Some of the unique items illustrated are:

**SOLAR-SKREEN™** — Safe, unsurpassed sunspot resolution . . . . . . . . . . . . *From $14.00*
**SOLAR PROMINENCE PROBE™** — See the prominences at the sun's limb. . . . . . . . . . . . *From $200.00*
**STEREOOCULAR™** — New three-dimensional viewing effect . . . . . . . . . . *From $244.00*
**ASTRO-TULE™** — Focus camera with ease . . . . . . . . . . *From $32.95*
**STAR-TRAP™ ILLUMINATED EYEPIECE RETICLE** — New model with built in LED's, battery, and reticle . . . . . . . . . . *From $44.95*
**LOW COST** 1-1/4" Orthoscopic and Erfle Eyepieces and Prism Diagonals. . . . . . . . . . *From $19.50*

Satisfaction guaranteed
or your money back

ROGER W. TUTHILL, INC.
Box 1086A, 11 Tanglewood Lane
Mountainside, N.J. 07092
(201) 232-1786

SEND FOR FREE CATALOG
Your name monogrammed free



SKY ALMANAC

# PLANETS GO A.W.O.L.

"What is so rare as a day in June?" a poet once asked. The answer to his question — at least this year — might be, "A planet in June." As most of the bright planets are either fading rapidly or are too close to the sun for worthwhile viewing, planetary observers will find it necessary to shift temporarily to a different subject. These conditions will last most of the summer, and the disadvantages of having the planets bunched together in the same part of the sky should now be obvious.

### Mercury

Mercury will reach greatest western elongation on June 15, at which time its separation from the sun will be 23 degrees and its magnitude +0.7. Despite these apparently favorable conditions, however, this will not be a particularly suitable time to observe the smallest planet — certainly not as good as April's greatest eastern elongation. The angle of the ecliptic is such that Mercury will be only about 11 degrees above the horizon at sunrise on its elongation date, so unless you have an empty horizon line and a clear morning, you'll probably miss this elusive planet. A much better western elongation will take place this year in October.

### Venus

Venus will be in superior conjunction with the sun on June 17. Then, it will be located on the opposite side of the sun from Earth, moving into the western sky and becoming an evening object. It will not be in a good position for observing, though, until much later in the year; Venus is too close to the sun all month to be seen.

### Mars

Midway through June, Mars will move from Cancer into Leo. Still visible in the west at sunset, Mars is continuing to move away from Earth and will do so until October; during June, it travels from 182 to 201 million miles from us. Mars' magnitude decreases to +1.9 by month's end, but since it is in a fairly dull region of the sky, it should be easy to find. On the 30th, Mars will be close to Regulus, the brightest star in Leo.

### Jupiter

Becoming more easily visible in the morning sky, Jupiter rises about two hours before the sun and is situated in the constellation Aries. It will not be seen in a completely dark sky until late in the month, and telescopic observation will be more profitable later in the year — although some observers report that the reduction of the planet's glare in a twilight sky makes possible the detection of more subtle details and color variations in Jupiter's belts. Try viewing it yourself during twilight on a June morning.

Now beginning its annual return visit to our planet, Jupiter closes its distance from 546 to 523 million miles from our planet. Its angular diameter is about 32 seconds of arc most of the month, and its magnitude is -1.7.

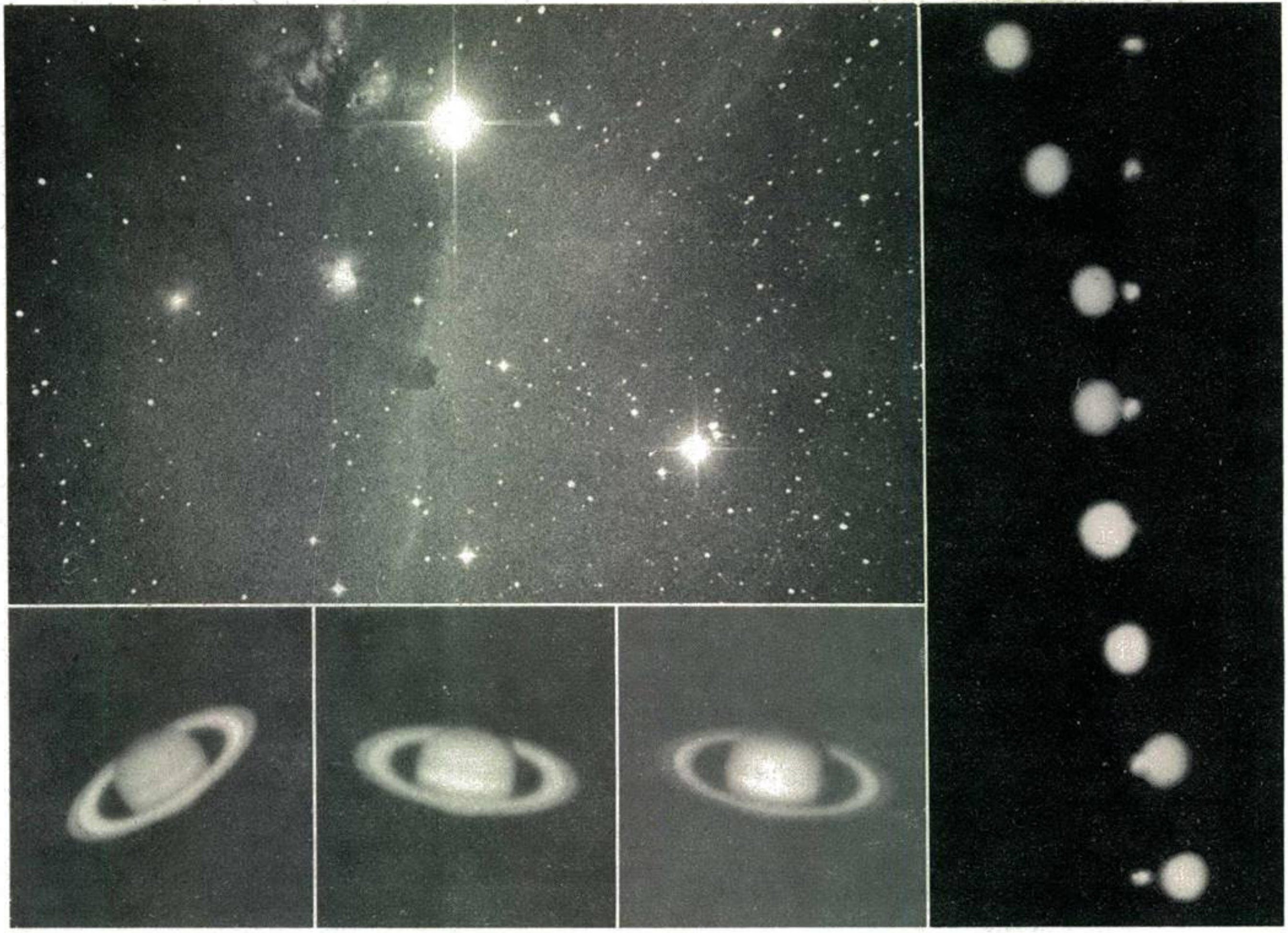
### Saturn

In Cancer, Saturn is far down in the west at sunset — itself setting about two hours afterward. Its magnitude all month is +0.5 — about as dim as the planet ever gets — and by month's end it is 931 million miles from Earth.

Since Saturn, as well as Jupiter, will be in the sky during twilight this month, why not try observing it at this time? This could provide a good basis of comparison of exactly how much detail is visible on both the giant planets.

### Uranus, Neptune

Uranus is still well placed for evening observation. Located in Virgo, the planet is of magnitude +5.7 and can be identified with binoculars, or even the naked eye, if the sky is clear and dark. A locator map appeared in ASTRONOMY's March issue.



Neptune reaches opposition on June 2. On that date it will be at its closest to Earth — a mere 2 billion 723 million miles away! The seventh magnitude planet is located in Ophiuchus (see last month's map).

If your telescope has an aperture eight inches or larger, you may be able to catch a glimpse of Triton, Neptune's larger moon. Its exact diameter is uncertain, but Triton may be the largest satellite in the solar system — even larger than Saturn's Titan. At its brightest, Triton is magnitude 13.6, so you'll need to look carefully if you want to see it.

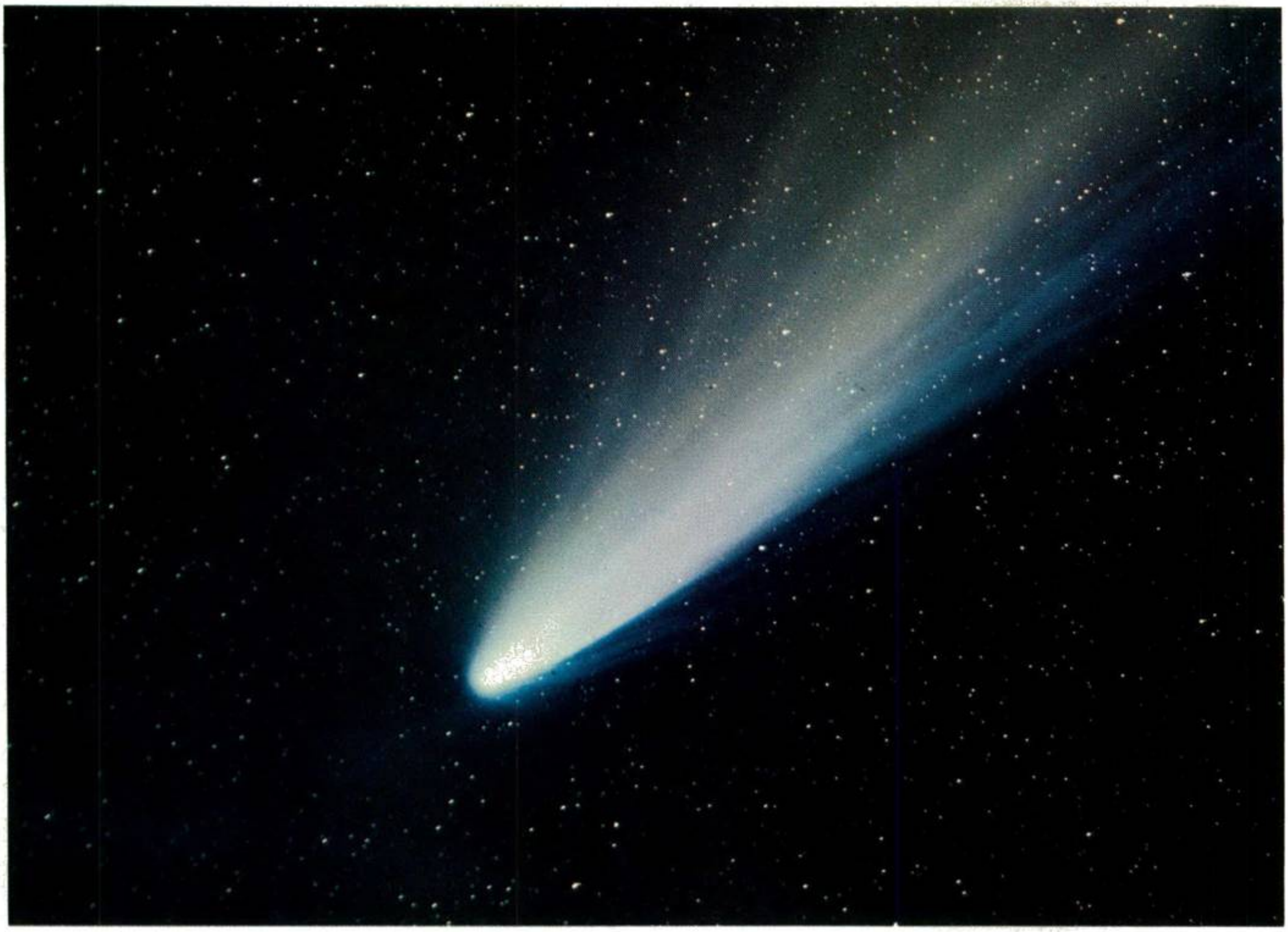
### Summer Begins

Summer officially starts when the sun reaches the summer solstice: that point in its annual path around the sky at which it is farthest north of the equator. The event takes place this year on June 21 at 2:24 a.m. EDT — meaning that summer will start the day before for west coast dwellers, about a half hour prior to midnight. This, however, is only the *official* beginning of the season; summerlike weather will hopefully have prevailed for some weeks before the solstice.

### Observations

Three totally different celestial events captured the attention of most observers in recent months.

The photographs on these two pages represent a wide variety of subject matter, from atmospheric phenomena to deep sky objects. An example of the latter is the picture (above left) of the Horsehead nebula, taken through a homemade eight inch Gregory-Maksutov telescope. The same instrument was used for two of the Saturn photos above. The one at left was taken on Jan. 9, near the planet's opposition date; the photo at center was made a month later. Both pictures were made at f/15 on Tri-X film. Photographs by George Nalisnik. The Saturn photo at right is a seven second exposure on SO-410, made through a Celestron 8 on Feb. 12. Photograph by James Rouse. The recent occultation of Epsilon Geminorum by Mars provided many astrophotographers with an opportunity to obtain an interesting sequence of pictures. The one shown (above right) depicts various stages of the occultation, including immersion at 7:56 p.m. EST and emersion slightly more than four minutes later. These exposures, all 1/2 second on Tri-X film, were taken by the afocal system through an eight inch home built Newtonian reflector at f/5. Photographs by Bob Kimmel. Opposite page, upper left: Great amounts of solar activity produced spectacular aurorae in Earth's atmosphere during the last days of March. This photograph, taken March 25 from Rochester, Mich., shows the view toward the eastern horizon; the constellation Lyra shines through the aurora at the top. This exposure was made on High Speed Ektachrome through a 35mm f/1.8 lens. Photograph by Randy Borst. Upper right: Comet West, one of the most often photographed comets in history, blazes in a California sky in this three minute exposure on GAF 200. A 50mm lens at f/2.8 was used for this March 7 picture. Photograph by Jack B. Child. Bottom: By April 5, comet West had faded considerably and moved into the constellation Delphinus. This 10 minute exposure on Fujichrome R-100, obtained with a 200mm f/3.5 lens, shows a nucleus of approximately fifth magnitude and a tail about one degree long. The amount of detail visible in the tail was diminished considerably. Photograph by George Briggs.



**This superb photograph of comet West, taken from the MacLean Observatory at Sierra Nevada College, shows intricate tail structure visible on March 9. This 15 minute exposure on High Speed Ektachrome was obtained with a 14 inch Celestron Schmidt telescope. Photograph by Dr. Leo Connolly.**

Caption for pages 52 and 53

**The photograph of comet West on the preceding pages is a composite of three different pictures obtained from the Mojave Desert on March 13; one was made on blue sensitive IIa-0 film, one on yellow sensitive IIa-D, and third on IIa-D with a yellow filter. A four inch f/5 home built refractor was used for all three exposures. Photograph by Rev. Ronald E. Royer and Steve Padilla.**

By mid-April, comet West had diminished greatly from the glorious sight it had provided at the beginning of March, but it was still much brighter than original predictions had stated. As it sped away from the sun, the comet had moved into the constellation Delphinus in April, visible for more than an hour before sunrise. At sixth magnitude, it was a fine sight in binoculars; the visible portion of its tail had shrunk to about one degree in length.

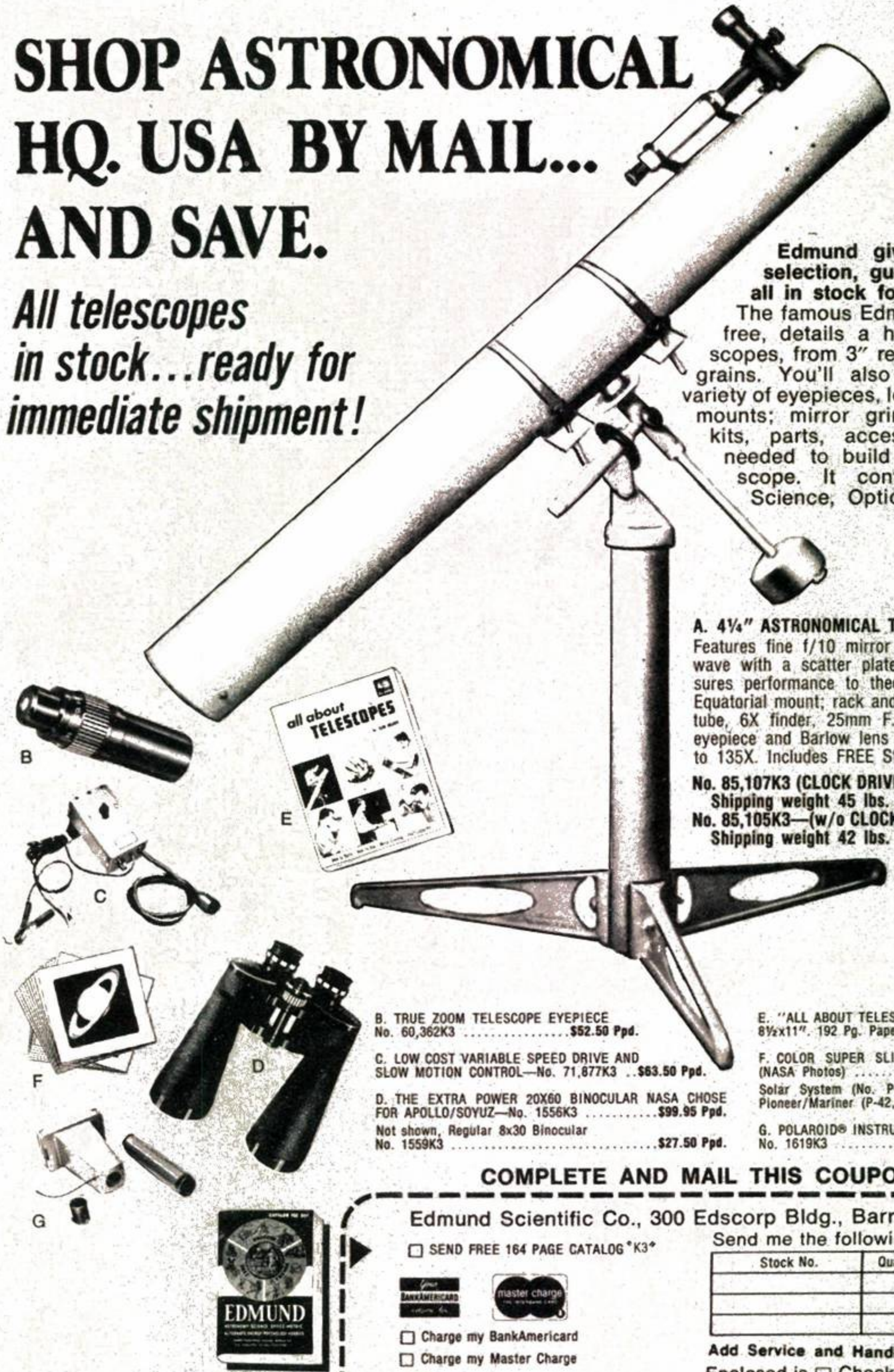
Interest was focused primarily on comet West's nucleus, which had broken into four sections during the comet's perihelion passage. Nucleus C had disappeared by March 28, while B and D became generally brighter. (B was reported as being brighter than A, the main nucleus, on March 29.)

While the great comet of the decade slowly faded, another unusual event was widely observed on the evening of April 7, when Epsilon Geminorum was occulted by Mars. Exact timings of the occultation varied, depending on latitude, but most observers saw Mars cover the star for slightly more than five minutes. The two objects were readily distinguishable from one another up to the instant of disappearance, with Mars' red-orange color contrasting with the yellowish-white hue of Epsilon. Since Mars was in a gibbous phase (easily visible through a telescope), the dark limb of the planet was the first to cover the star, which disappeared abruptly. Most observers who viewed the occultation reported seeing the star dim noticeably in the last half second before it disappeared, and return to its original magnitude a half second after reappearing — an effect produced as the star's light passed through Mars' atmosphere.

Massive auroral displays took place during the last week of March after a period of intense solar activity. Large flares on the sun's surface whipped up great magnetic storms, and ionic particles that streamed into space produced spectacular aurorae shortly thereafter. Those favored with good sky conditions witnessed the bright red glow in the northeast, climbing as high as 75 degrees above the horizon — almost to the zenith. In some places, the aurora's shimmering, shifting glow was reported to be as bright as the full moon.

# SHOP ASTRONOMICAL HQ. USA BY MAIL... AND SAVE.

*All telescopes in stock...ready for immediate shipment!*



**Edmund gives you the largest selection, guarantees every item, all in stock for speedy delivery.** The famous Edmund catalog, offered free, details a huge display of telescopes, from 3″ reflectors to 8″ Cassegrains. You'll also find a tremendous variety of eyepieces, lenses, finders, drives, mounts; mirror grinding and polishing kits, parts, accessories — everything needed to build or equip your own scope. It contains 4500 unusual Science, Optical, Hobby values!

**A. 4¼″ ASTRONOMICAL TELESCOPE**

Features fine f/10 mirror (verified better than 1/10 wave with a scatter plate interferometer) which insures performance to theoretical limit of resolution. Equatorial mount; rack and pinion focusing; aluminum tube, 6X finder, 25mm F.L. 45X Kellner achromatic eyepiece and Barlow lens to double and triple power to 135X. Includes FREE Star Chart, 2 Books.

**No. 85,107K3 (CLOCK DRIVE)**
**Shipping weight 45 lbs. ............ $199.50 FOB**
**No. 85,105K3—(w/o CLOCK DRIVE)**
**Shipping weight 42 lbs. ............ $159.50 FOB**

B. TRUE ZOOM TELESCOPE EYEPIECE
No. 60,362K3 ................ **$52.50 Ppd.**

C. LOW COST VARIABLE SPEED DRIVE AND SLOW MOTION CONTROL—No. 71,877K3 .. **$63.50 Ppd.**

D. THE EXTRA POWER 20X60 BINOCULAR NASA CHOSE FOR APOLLO/SOYUZ—No. 1556K3 ........... **$99.95 Ppd.**

Not shown, Regular 8x30 Binocular
No. 1559K3 ............................ **$27.50 Ppd.**

E. "ALL ABOUT TELESCOPES"—BY SAM BROWN, 8½x11″. 192 Pg. Paperback. No. 9094K3 ..... **$4.95 Ppd.**

F. COLOR SUPER SLIDE SETS (20 EA.) FROM SPACE (NASA Photos) ........................ **$6.95 ea. Ppd.**

Solar System (No. P-42,350K3); ERTS (P-42,349K3); Pioneer/Mariner (P-42,351K3); Mars Launch (P-42,352K3).

G. POLAROID® INSTRUMENT ASTRO CAMERA
No. 1619K3 ............................ **$71.95 Ppd.**

**COMPLETE AND MAIL THIS COUPON NOW**

Edmund Scientific Co., 300 Edscorp Bldg., Barrington, N.J. 08007

☐ SEND FREE 164 PAGE CATALOG "K3"

Send me the following:

| Stock No. | Quantity | Price Ea. | TOTAL |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Add Service and Handling Charge $ $1.00

Enclosed is ☐ Check ☐ M.O.
in amount of $

☐ Charge my BankAmericard
☐ Charge my Master Charge

Interbank No. ________

Card No. ________

Expiration Date ________

30-DAY MONEY-BACK GUARANTEE. You must be satisfied or return any purchase in 30 days for full refund.

Signature ________

Name ________
(Please Print)

Address ________

City ________

State ________ Zip ________

**EDMUND SCIENTIFIC CO.**
300 Edscorp Bldg., Barrington, N.J. 08007

(609) 547-3488

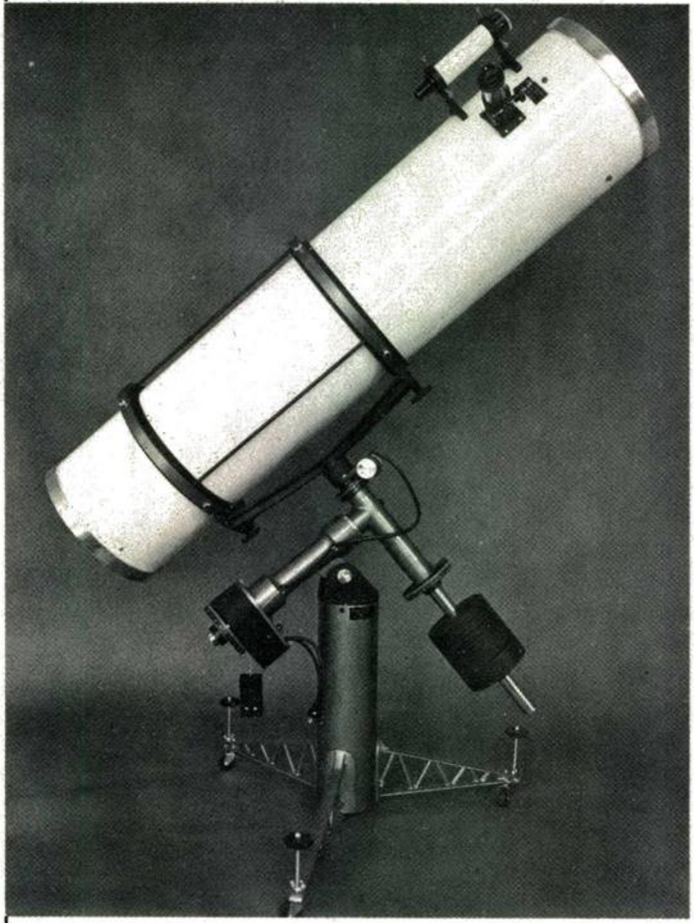
**ASTRONOMICAL HQ. USA**
America's Greatest Science, Optics and Hobby Mart.

**HELPING TO DEVELOP AMERICA'S TECHNOLOGY FOR OVER 30 YEARS**

# *Cave* ASTROLA

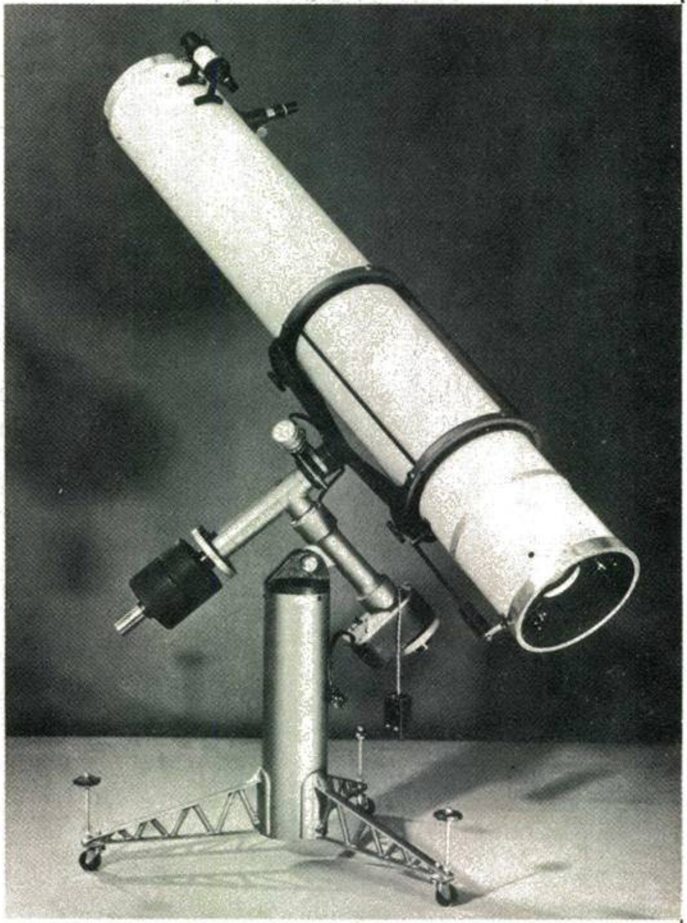
*WHY ARE THESE TWO NEWTONIANS YOUR BEST TELESCOPE VALUES?*

American Made — Nationally Available on Extended Payment Terms.



12" DELUXE SUPER COMPACT NEWTONIAN — $1295

*This new ASTROLA f/5 reflector's 15-inch diameter tube is only five feet long. You'll use it for very high-performance general work, and for rich field observations as well. Here's an observatory size, observatory quality instrument for your permanent station, or your field trips. One-man set up and operation make it truly portable. With its specially engineered, rigid but light-weight mounting, total weight is but 150 pounds—yet it has 50% more light-collecting power than a 10" reflector, for exciting galactic explorations. Like all telescopes manufactured at the Cave plant, it has a diffraction-limited primary mirror, accurately machined castings, with large tapered double-race ball-bearings. Four, top-quality eyepieces are included.*



10" DELUXE NEWTONIAN — $895

*If you haven't the budget for a larger instrument, but want the best performance possible for your dollars, consider this beautiful 10-inch ASTROLA. Compared to popular 8-inch reflectors, it gives 1½ times the light-gathering power, and less internal diffraction, for better resolution. The mount is heavier, with saddle twice as long. Remember, with any ASTROLA you get truly superb performance—guaranteed by our optical department, which has figured over 21,000 large optical surfaces during 25 years operation. A complete line of high quality optional accessories for your observing needs is also available from Cave Optical Company, the nation's oldest supplier of fine telescopes.*

NOTE—Prices f.o.b. factory. Crating charge for these instruments is $40.

**ASTROLA NEWTONIAN REFLECTORS**

*(Selected from more than 40 available models and sizes)*

| | | |
|---|---|---|
| **6"** | Student Standard | $ 280.00 |
| | Student Deluxe | $ 385.00 |
| | Model "A" Deluxe | $ 565.00 |
| **8"** | Lightweight Standard | $ 370.00 |
| | Lightweight Deluxe | $ 595.00 |
| | Model "B" Standard | $ 460.00 |
| | Model "B" Deluxe | $ 720.00 |
| **10"** | Model "C" Standard | $ 590.00 |
| | Model "C" Deluxe | $ 925.00 |
| **12-1/2"** | Transportable | $1475.00 |
| | Permanent-Pier Observatory | $2490.00 |
| **16"** | Permanent-Pier Observatory | $4490.00 |

**Exclusive distributors of MAGNUSSON setting circles and CARLE Photo-Visual Focusers and CARLE Camera Adaptations.**

**CAVE TELESCOPE MIRRORS**

(Price includes diagonal and aluminizing)

| | New | Refiguring |
|---|---|---|
| 6" | $ 79.00 | $ 52.00 |
| 8" | $115.00 | $ 68.00 |
| 10" | $197.00 | $110.00 |
| 12-1/2" | $325.00 | $175.00 |
| 16" | $990.00 | $600.00 |

**America's largest selection of oculars, focusers, tubes, finders, cells, spiders, mountings, drives, circles, remote slow motions, and other telescope parts and accessories.**

**SEND CURRENCY OR STAMPS FOR YOUR 30-PAGE COLOR CATALOG A1976.**

*($1.00 U.S. RESIDENT, $2.00 OUTSIDE THE U.S.A.)*

**CAVE OPTICAL COMPANY**
4137 E. ANAHEIM STREET
LONG BEACH, CALIFORNIA 90804
**Telephone 213-434-2613**

Factory showroom open Tuesday through Saturday — 9 A.M. to 5 P.M.

# ASTRO-MART

FOR SALE — 3" (45" f.l.) Edmund objective lens (stock no. 50,162); never used; $45.00. Unitron 60mm (900mm f.l.) objective lens with cell, dewcap. Excellent condition; $45.00. Write Dale B. Chapman, 1748 Oakmount Rd., Cleveland, OH 44121.

FOR SALE — Quadrupod pedestal base, heavy gauge cast iron, 18" oak legs; takes standard 3" mount cap. Contact James B. Clark, P.O. Box 627, Woodland, CA 95695. Phone (916) 662-7971.

FOR SALE — 2.4" refractor with adjustable metal tripod, lens, 5 x 24mm sighting scope, main tube carrying pouch. Good condition. Price: $40.00. Write Russ Cohen, 12 Argyle Dr., East Islip, NY 11730. Phone (516) 581-7805.

FOR SALE — Cave 10" deluxe Newtonian with rotating tube, solar screen, 2 eyepieces. Tube assembly only. Perfect condition; 1 year old. Price: $275.00; will deliver in northeast. Write R. Alfano, 81 Fernwood Ave., Oakdale, NY 11769.

FOR SALE — Celestron 8 with tripod, wedge, Dakin Barlow. Excellent condition. Price: $950.00 plus shipping. Write Harry E. Beams, 2201 S. 14th St., Springfield, IL 62703.

FOR SALE — AC-DC variable speed drive corrector (sold by Celestron). Excellent working condition; 2 years old. Price: $60.00 firm; will ship in U.S. Write Martin C. Germano, P.O. Box 3605, Thousand Oaks, CA 91359.

FOR SALE — 10" Star-Liner mount with circles, drive, pedestal; $300.00. 8" mirror, mount, eyepiece focuser, equatorial mount, Jaegers' K-22mm; $100.00. 3x Dakin Barlow; Brandon 16mm; Brandon 32mm; $30.00 each. Contact William R. Gilman, 604 Eastbrooke Ln., Rochester, NY 14618. Phone (716) 461-5649.

FOR SALE — Criterion RV-6 with special 98% reflective coating on mirror, 3 eyepieces, slow motion on declination, Geisler variable frequency power supply, extra counterweights, wooden case. New, $475.00. Asking $350.00 Write Murray McEwan, Box 658, Tisdale, Saskatchewan, CANADA S0E 1T0.

FOR SALE — Dynamax 8 with stand, accessories, variable speed drive, T-mount for Minolta 101 camera, Solar Skreen rigid 4-1/2" pier stand. One year old. Price: $900.00. Contact George R. McKee Jr., 2306 Mulberry Ln., Lafayette Hill, PA 19444. Phone (215) 828-3351.

FOR SALE — Cave 10" Cassegrain without mount or equatorial head. Excellent condition. Price: $600.00. Contact Jerald W. McPherson, 308 St. Clair St., Starke, FL 32091. Phone (904) 964-5371.

FOR SALE — Complete Criterion RV-6 Dynascope with eyepieces; very good condition. Price: $165.00. Also 10" Cave reflector with simple equatorial mount, wide-angle eyepiece; excellent condition. Price: $375.00. For further details, write Charles Connacher, Gallitzin Rd., Cresson, PA 16630.

FOR SALE — Brand new 3-1/2" Questar Duplex with Cer-Vit mirror, special coatings, many Questar accessories. Worth over $2,100.00. Price: $1,500.00 or best offer; must sell. Contact Stephen B. Ganderson, Box 2, FPO Seattle, WA 98790. Phone (907) 487-3361.

FOR SALE — 2.4" refractor with equatorial mount, setting circles, 4 oculars, 6 x 30 finder, 2x Barlow, diagonal prism, filters, complete solar equipment, Argus 75 camera for astrophotography. Price: $220.00. Contact Laird Calia, 630 N. Mary St., Lancaster, PA 17603. Phone (717) 393-0839.

**AMATEUR RADIO ASTRONOMER'S NOTEBOOK**
**$20.00 POSTPAID IN U.S.A.**

Prepared by successful amateurs for amateurs 96 page projects manual contains assembly plans for

- Pen recorders and data reduction
- Simple solar noise storm receivers
- Antenna and preamplifier construction
- Jupiter noise storm receiver
- High resolution 32 to 64 cm interferometer

Emphasis is on maximum performance and ease of construction with readily obtainable parts and assemblies

FREE WITH ORDER CASSETTE TAPE OF RADIO NOISES OF 6 PULSARS, JUPITER, AND A TYPE III SOLAR BURST

**BOB'S ELECTRONIC SERVICE**
**817 NORTH ANDREWS AVE. FORT LAUDERDALE, FLA. 33311**

**AUTHORS WANTED BY NEW YORK PUBLISHER**

**Leading book publisher seeks manuscripts of all types: fiction, non-fiction, poetry, scholarly and juvenile works, etc. New authors welcomed. For complete information, send for free booklet W-79. Vantage Press, 516 W. 34 St., New York 10001**

**MARS 76**

**Mars '76**
**Bumper Sticker**
**in**
**Red, White, Blue**
**$1.50 Ppd.**
**Send to**
**D. L. Drummond**
**11 Vinal**
**Brookline, Mass.**
**02146**

FOR SALE — 8" f/5 Superior Optics RFT; aluminum tube, 20mm Erfle, no mounting. Price: $200.00 plus shipping. Also 2.4" Tasco refractor with accessories; best offer. Contact Greg Slusaw, Box 400, R.D. #1, Coplay, PA 18037. Phone (215) 262-4953.

Advertise it free in Astro-Mart.

FOR SALE — 6" RV-6 Dynascope with equatorial mount, tripod, setting circles, clock drive, circular spider, tube end protectors, Criterion 8 x 50 finder. Price: $195.00 or best offer. Contact Eric M. Bram, 6146 Waterman, St. Louis, MO 63112. Phone (314)721-6360 or 721-1122.

FOR SALE — Unitron 80mm spotting scope; brand new; $150.00. Also 6" f/10 Coulter mirror, secondary, 50mm f/5 objective, 2 eyepeces; complete optical system for 6" scope; $40.00. Contact Bruce E. Marten, P.O. Box 51, Sausalito, CA 94965. Phone (415) 332-0614.

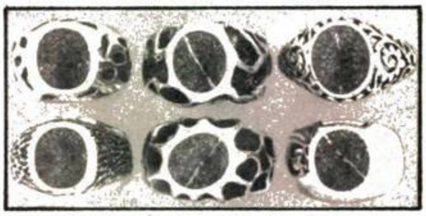
**BUILT BETTER BY BYERS**

*Precision Mountings & Telescopes*

*Driving Systems:*

**Edward R. Byers Co.**
**29001 W. Highway 58**
**Dept. AM,**
**Barstow, CA. 92311**
**Phone (714) 256-2377**

**METEORITE RINGS**
*Now in 14Kt. Gold or Sterling Silver*



The only rings on Earth with stones from outer space. Only $28.50 in sterling silver or $85.50 in 14kt. gold. For free brochure write: **HOUSE OF RINGS**
**P.O. Box 6127, Dept. AM,**
**Kansas City, MO 64110**
*Phone: 816-363-2002*

FOR SALE — 11 x 80mm binoculars with case, straps, built-in and separate camera tripod adapter. New; was $170.00; asking $130.00. Contact S. Saul, 3 Theodore Dr., Plainview, NY 11803. Phone (516) 938-3171.

FOR SALE — 6" f/5 RFT refractor, large focusing unit, equatorial mount, pedestal, electric drive, 2 eyepieces. Asking $480.00. Over 40 eyepieces at substantial savings. Contact S. Saul, 3 Theodore Dr., Plainview, NY 11803. Phone (516) 938-3171.

FOR SALE — Back issues of ASTRONOMY: August 1973 through December 1975. Complete set; mint condition. Price: $100.00. Write B. C. Miller, 3803 St. Barnabas Rd. - #202, Suitland, MD 20023.

**GLOBES/SLIDES/TELESCOPES**

| | | |
|---|---|---|
| CS-103 Astro Globe | 13-1/2" high | $39.95 |
| CA-101 Astro Globe | 23-1/2" high | $175.00 |
| NASA Lunar Globe | 12" dia. | $16.95 |
| Celestial Globe | 12" dia. | $18.95 |
| Lunar Globe | 6" dia. | $ 6.95 |
| Mars Globe | 6" dia. | $ 6.95 |

Add $2.00 ea. postage/insurance

**MMI ASTRONOMICAL TELESCOPES**

Write for **FREE** catalog
on all Astronomy materials

**COLOR SLIDES**, 10-20/set-Sun, Earth, Moon, Planets, Star Clusters, Galactic Nebulae, Milky Way, Satellites. Write.

**NASA COLOR SLIDES**, 24/set Gemini-Apollo w/book, Lunar surface & Orbit $8.95/set, Add $0.75 shipping

**MMI CORPORATION, Dept. A**
**3016 Cresmont Avenue Baltimore, Md. 21211 (301) 366-1222**

**SHADOW OF THE MOON** Eclipse-Australia—New Zealand—Tahiti Tour departs Los Angeles October 15 returns October 31. First Class hotels - college credit. Conducted by Ronald L. Smith, Instructor, lecturer in Astronomy. *$1599*. **KERR TRAVEL SERVICE, Dept. AM, 9301 Wilshire, #502, Beverly Hills, CA 90210.**

**LOST IN SPACE?**

Let us be your guide.

**Coast Navigation School**

**SCHOOL OF ASTRONOMY**
**Dept.** 5320 **418 E. Canon Perdido**
**Santa Barbara, California 93102**

Please send me your home study course catalog.

name

address

city state zip

***Accredited Member National Home Study Council***

FOR SALE — 10" Cassegrain mirror, perforated; needs final figuring (about 1/3 wave accurate now); 2.75" completed secondary; spacing; formulas; $150.00. Sears 4.5" reflector with equatorial, clock drive, camera holder; $75.00. Contact William R. Gilman, 604 Eastbrooke Ln., Rochester, NY 14618. Phone (716) 461-5649.

FOR SALE — Cave 8" f/8 model "B" deluxe reflector with drives on both axes, 2" focuser, 3 orthoscopic eyepieces. Must sell. Price: $140.00. Contact David Hartsel, 917 Cleveland Ave., Ashland, OH 44805. Phone (419) 324-6592 after 5 p.m.

FOR SALE — Partially completed 6" f/8 telescope mirror; only needs final correcting, parabolizing. Includes 4 oz. cerium oxide, 8 oz. burgundy pitch, University Optics Mir-o-test. Price: $45.00. Write David B. Hawthorne, 24 Dartmouth Dr., Hazlet, NJ 07730.

FOR SALE — 4-1/4" Edmund reflector with Kellner eyepiece, Barlow, 6x finder, all metal mount, setting circles. Price: $70.00. Write Marty Heitz, 159 Antwerp Ave., Egg Harbor City, NJ 08215.

FOR SALE — Dynamax 8, complete. Price: $775.00. Contact Frank Holderby, 102 Wynn Pl., Warner Robins, GA 31093. Phone (912) 923-1046.

FOR SALE — Criterion RV-6 Dynascope with 2 eyepieces (9mm, 18mm), optional Barlow, clock drive. Like new; less than 1 year old; must sell. Price: $190.00 plus shipping. Contact Stanley Holz, 4 Libbey St., Whitefield, NH 03598. Phone (603) 837-9194 after 5 p.m.

FOR SALE — 6" Edmund reflector with equatorial mount, pedestal base, clock drive, 3 eyepieces, Barlow, solar screen, camera mount. Excellent condition. Price: $100.00 plus shipping. Write Bill O'Donnell, 64 Charles St., Carteret, NJ 07008.

FOR SALE — 12-1/2" f/9.6 Newtonian, electric focus (12 volt), massive equatorial pier mounting. Good condition. Price: $550.00; will deliver free within 300 miles. Write R. D. Brant, 7205 Hamlet Ct., San Diego, CA 92120.

FOR SALE — Back issues of ASTRONOMY (June 1974 through May 1976). All in very good to excellent condition. Price: $40.00 or best offer. Write Belinda Reuther, 423 N. 9th St., Breckenridge, MN 56520.

FOR SALE — 4-1/2" Sears reflector with equatorial mount, electric drive, 5 oculars, 6x finderscope, 2 ring mounts, tripod. Price: $170.00 (cash or check). Write Carl V. Robertson, 4299 Trout Dr. S.E., St. Petersburg, FL 33705.

FOR SALE — 3" f/11 Maksutov telescope with 3 eyepieces (28x, 50x, 92x), fork mounting, equatorial head adapter for mounting on pedestal or tripod. Brand new; was $265.00; asking $190.00. Contact S. Saul, 3 Theodore Dr., Plainview, NY 11803. Phone (516) 938-3171.

FOR SALE — 80mm super spotting scope; custom optics, 6 eyepieces (15x to 60x), table tripod, adapter for camera tripod. Brand new; was $210.00; asking $155.00. Contact S. Saul, 3 Theodore Dr., Plainview, NY 11803. Phone (516) 938-3171.

FOR SALE — Cave deluxe equatorial mount modified for 12-1/2" scope; massive clock drive, electronic declination control, 1-1/2" steel shafting, counterweight. Never used; new, $550.00. Price: $450.00 or best offer plus freight. Contact Bill Sterne Jr., 4249 E. 25th Pl., Tulsa, OK 74114. Phone (918) 932-5122.

FOR SALE — 4-1/2" Tasco reflector with setting circles, slow motion controls, 5' wooden tripod, eyepiece rack, 2 eyepieces, 2x Barlow, 5x finderscope. Good condition. Price: $75.00. Contact Dushan Stevanovich, 3911 W. 55th St., Chicago, IL 60632. Phone (312) 767-4138 evenings.

FOR SALE — All back issues of ASTRONOMY; all in excellent condition except January 1974. Asking $125.00 for complete set, or $75.00 for first 13 issues. Contact Dennis Thorpe, 538 Locomotive St., Irvine, KY 40336. Phone (606) 723-4479.

FOR SALE — Davis and Sanford tripod with pan head. Like new. Price: $80.00. Write Richard C. Utterbeck, 4701 N. Arden Dr., El Monte, CA 91731.

FOR SALE — 8" Cassegrain, equatorial mount on tripod, 10x (40mm) Unitron finder, 3 oculars (6mm, 12mm Orthoscopic, 40mm Kellner), prism star diagonal. Seldom used. Price: $500.00. Write L. Robert Kyllo, R.R. #1, Box 116, Preston, MN 55965.

FOR SALE — University Optics 20 x 80 binoculars with straps, lens caps, case. Seldom used; less than 1 year old. Price: $95.00; includes insurance and shipping in original box. Write Tom Webb, 248 Estrada Ave., St. Augustine, FL 32084.

FOR SALE — Complete set of ASTRONOMY magazines: Vol. 1, No. 1 (August 1973) through Vol. 3, No. 12 (December 1975); excellent condition. Do not wish to break set; make offer. Write Bill Welker, 1709 Field Dr., Enid, OK 73701.

FOR SALE — Stellar 40 x 40mm refractor with 10" tripod. Scope is in good condition; tripod has been repaired. Price: $12.00. Write John Wetsch, P.O. Box 277, Killdeer, ND 58640.

FOR SALE — Complete set of ASTRONOMY magazines (August 1973 through April 1976) in mint condition. Might be willing to sell separately. Highest offer. Write Norman R. Williams, 1023 Ashridge Ln., Park Forest South, IL 60466.

FOR SALE — 8" f/8 Jaegers aluminized mirror, 12mm Kellner eyepiece, Barlow, elliptical diagonal. All for $100.00, or will sell separately. Contact Rick Young, 90 Whitney St., Westbury, NY 11590. Phone (516) 333-2231.

FOR SALE — 4-1/4" Edmund Newtonian reflector; aluminized, overcoated mirror; clock drive. Excellent condition, 2 years old. Price: $130.00. Contact Ronald Ziss, 6533 N. Christiana, Lincolnwood, IL 60645. Phone (312) 677-1287.

FOR SALE OR TRADE — 10" f/6.5 aluminized mirror by Meridian Co. 10" mirror cell; 2.5" and 2" diagonals, both quartz, made by E & W Optical. Contact John W. Cross, 6307 Woodson Dr., Mission, KS 66202. Phone (913) 432-6541.

*continued on page 64*

# ASTRO-NEWS

Latest News From the World of Astronomy

## Frozen Methane Found On Surface of Pluto

Three visiting planetary scientists at Kitt Peak National Observatory have discovered a substantial amount of solid methane on the surface of Pluto.

Methane has been suspected as being an important constituent of the early solar nebula that formed the solar system over 4.5 billion years ago. Never before detected in solid form on any planetary or satellite surface, its presence raises questions about Pluto's true size.

The three astronomers, Dale P. Cruikshank, David Morrison and Carl B. Pilcher, all of the University of Hawaii, announced their findings at the seventh annual meeting of the Division of Planetary Sciences of the American Astronomical Society in Austin, Texas in March.

The astronomers measured Pluto's albedo at infrared wavelengths, using the observatory's 158 inch (four meter) reflector and specially constructed filters. The filters allowed the passage of only two narrow bands of infrared radiation centered at 1.54 and 1.71 micrometers. One band allowed the wavelength characteristics of water ice to pass, while the other allowed the same characteristics of methane to slip through. "On Pluto," Cruikshank said, "the response of (the) filters was exactly as expected for methane ice."

To check the obtained observations, several of Saturn's moons — Dione, Rhea, Iapetus and Tethys — were scrutinized. "These objects showed only the spectral signature of water," Cruikshank said, substantiating the findings presented at the same conference of four University of Arizona astronomers. One scientist at the meeting pointed out that any of the moons might have up to 30 percent methane that would remain undetected with the amount of water present.

Methane has been found in gaseous form in the atmospheres of Jupiter, Saturn, Titan (one of Saturn's satellites), Uranus, Neptune and Earth. It's presence on this planet is primarily due to biological activity.

The discovery of solid methane on Pluto provides direct evidence that the planet's surface temperature can be no higher than -373 degrees Fahrenheit. Models of the condensation process of the primordial solar nebula posit that methane might freeze and form on accreting planetary-like bodies if the temperature within the nebula fell below -373 degrees.

Cruikshank observed that the presence of frozen methane on Pluto indicates the temperature was this low when the planet formed. Because Pluto is so distant from the sun (its mean distance is 3.7 billion miles) and receives such a feeble amount of heat, the methane may have remained undisturbed since the solar system's birth.

If most of Pluto's surface is covered with methane ice, the Hawaiian scientists' observations of the planet's reflectivity indicate it is brighter than our moon over comparable areas. "If this is true," Morrison said, "Pluto will prove to be a substantially smaller planet" than current estimates indicate (3,600 miles in diameter). It may even, he added, be smaller than our moon.

The possibility exists that methane ice may exist on the moons of Neptune and Uranus, Cruikshank said. Observational measurements are being analyzed and there is a slim possibility that Oberon and Triton (Uranus' and Neptune's largest satellites, respectively) may contain some residual amounts of solid methane.

The outermost planet may be so small that accurate measurements of its mass from the observed perturbations on the true motions of Uranus and Neptune may be extremely difficult to obtain.

Solid methane is believed to cover portions of Pluto, rather than the entire surface. Earlier observations of the planet detected small fluctuations in its light. If methane ice covered the entire surface, no fluctuations in the small planet's albedo would probably be seen.

## 40th Interstellar Molecule Located Near Galactic Core

A team of radio astronomers at the Hertzberg Institute in Ottawa, Canada have discovered the organic molecule cyanodiacetylene ($HC_5N$) in a Sagittarius gas cloud near the center of the Milky Way.

The molecule is the heaviest yet detected in interstellar space. Like the previously discovered cyanoacetylene ($HC_3N$), the newly discovered molecule could combine with two water molecules to form glycine, the simplest amino acid. Amino acids are fundamental units of life which link together to form proteins. No amino acids have yet been found in space, mainly because astronomers do not know the frequencies at which amino acids radiate.

This latest discovery brings the number of interstellar molecules detected to 40. Some molecules have been found in more than one isotopic form; for example, both ordinary water and heavy water are known to exist in space.

All but three of the 40 discovered molecules have been detected by radio telescopes.

# Where Will Viking Landers Set Down?

Two identical Viking spacecraft are expected to soon end their nearly year-long journeys and go into orbit around Mars. The spacecrafts' primary missions are to locate safe landing sites and then proceed to search for evidence of extraterrestrial life on the surface of the red planet. The first craft will be inserted in orbit on June 19; the second on Aug. 7.

To determine which landing site is most desirable, a series of orbital reconnaissance flights will be made over four preselected sites. Three of the proposed sites are in low regions of the planet where a maximum atmospheric pressure is expected. The sites possibly were wet in the geologic past or have become damp with the changing Martian seasons. The ideal landing site, one Viking scientist said, will be relatively low, warm, wet, safe and interesting.

A close-up evaluation of each site will be made from orbit to determine surface roughness and elevation differences. Infrared thermal mapping of surface features and cloud top temperatures, infrared water vapor detection of humid areas and an analysis of the Martian atmosphere will detail landing site desirability.

Once a site has been determined, the Viking lander will separate from the orbiter and begin entry at 800,000 feet above the Martian surface. At this point, the lander is committed to the chosen site; it cannot subsequently reject this site and aim for another. The final descent stage will begin about 20,000 feet with parachute deployment to slow the craft's descent. At 4,000 feet, three retro-rockets will fire and continue firing until the lander is about 10 feet above the surface; they will then shut off and the lander will fall freely to the surface at about five m.p.h. The whole process, from entry to landing, will take 5 to 10 minutes.

Landing sites having boulders, slopes steeper than 19 degrees or very soft dusty surfaces must be avoided, though the lander performed well during tests at inclines of up to 25 degrees. The landing vehicle sits on three stubby legs that allow only nine inches of bottom clearance. It must remain nearly upright for its sophisticated instrumentation to properly function. Hopefully, all sites will be immune to the severe seasonal winds that would imperil a safe landing.

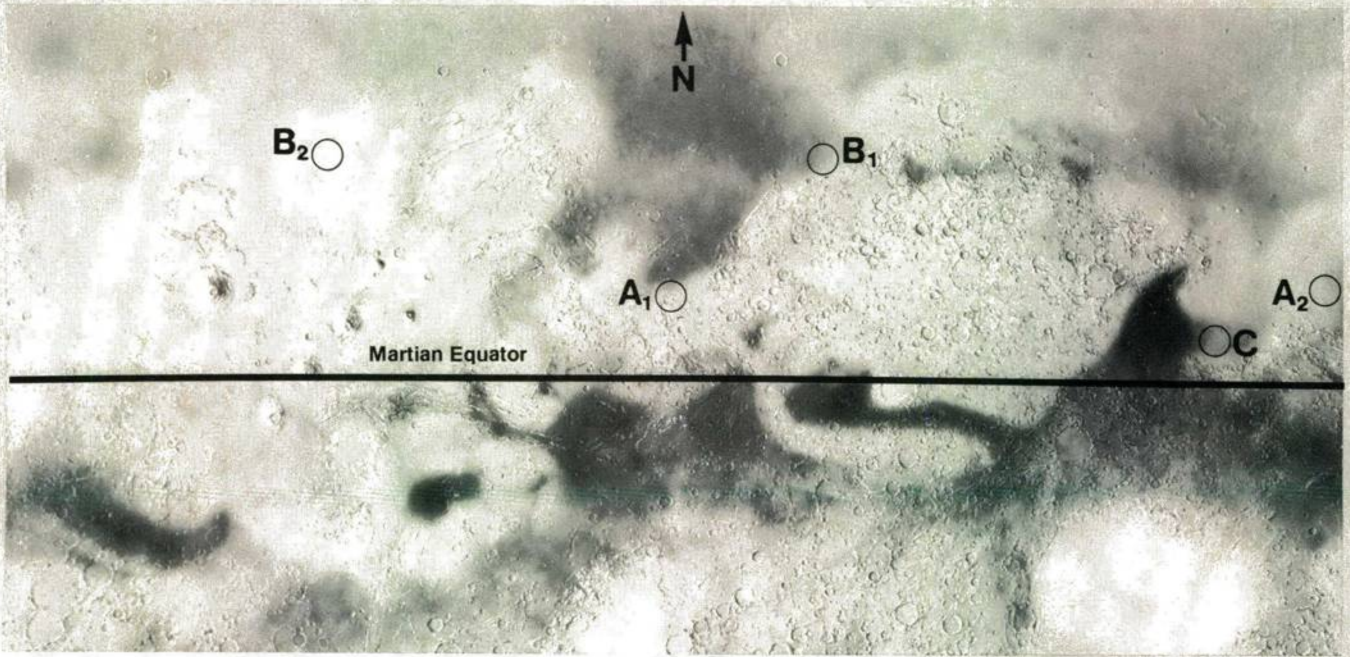
Two of the sites lie about halfway between the planet's equator and the edge of the summer north polar ice cap. Daytime temperatures may be high enough here to support life. A seasonal source of water vapor might be available from the thawing polar cap.

The other two landing sites lie at higher latitudes where the edge of the north cap covers the surface during the Martian winter. There may be water here in the form of ice or vapor as well as the "cold trapping" of organic material. If so, the Viking biological test equipment may detect existing life forms or evidence of fossil life.

If all goes well aboard the first spacecraft, Viking team scientists plan to celebrate the American bicentennial with humanity's first successful touchdown of an automated environmental laboratory on the surface of Mars on July 4, 1976, although that date is not firm. "The mission comes first," one Viking team scientist said.

The first Viking craft, launched Aug. 20, 1975, is labeled Mission A. It is tentatively scheduled to land in an area known as Chryse (the Greek word for gold), first named by Italian astronomer Giovanni Schiaparelli in 1877. The site lies on a gentle slope at the mouths of several large, sinuous valleys in a circular basin whose floor is about 10,000 feet below the mean surface pressure level. (Because Mars has no seas for use as a mean reference level, the Martian zero elevation reference point is defined at a 6.1 millibars atmospheric pressure. This is the minimum pressure at which water can exist in a liquid state at moderate temperatures. At pressures less than 6.1 millibars, water sublimates, passing directly from a solid to a vapor.)

The Chryse landing site's low eleva-



*Four possible landing sites have been chosen for the two Viking spacecraft. The first Viking mission may land at Chryse ($A_1$) or Tritonis Lacus ($A_2$). The second vehicle is scheduled to touch down at Cydonia ($B_1$) or Alba ($B_2$). Questions about the safety of the Mission A sites have led to the search for a third site. One very promising location is the Libya-Isidis Basin (C). Map by the United States Geological Survey, Department of Astrogeology.*

tion means a relatively high atmospheric pressure, needed for the presence of liquid water as well as the deployment of the craft's 55 foot landing parachute. The site location is also important to the biological and geological experiments of the mission.

If four meandering valleys in the southern portion of the Chryse region were carved by running water in the past — strongly suspected by astrogeologists — the Chryse basin is a likely place to search for ancient and present day life forms. If there was water action, there may be a wide variety of scientifically interesting Martian rocks and minerals transported from far-off highland areas.

There may be extended hard, rocky areas in the Chryse region that could give the surface sampler problems in locating loose soil to scoop up for biological sampling. Radar has indicated there are rather large sand dunes that could make the site unsafe.

Past telescopic observations have shown that the Chryse region has a history of seasonally controlled weather. During the Martian summer and winter — when either of the polar caps has nearly completed its thawing phase — observed bright patches appearing during the Martian morning were interpreted to be ice fogs or ground frosts formed during the chill of the Martian night. If this is correct, the local early morning wind velocity is probably light or calm.

However, there may be other climactic conditions present in the Chryse region. In May 1903, during the Martian summer, Percival Lowell saw a brilliant cloud projection on the morning terminator over Chryse. Modern observations have recorded a few instances of widespread yellow dust clouds in this region during the summer seasons, implying possibly strong winds of up to 300 m.p.h. lasting for several days.

If orbital reconnaissance shows the Chryse basin in undesirable, the spacecraft can be redirected to the alternate landing site, Tritonis Lacus, in Amenthes. The site lies in an area of smooth plains with infrequently small, bowl shaped craters near the eastern rim of the ancient Libya basin. Several large, partially buried craters lie to the south. The plains are believed to consist largely of debris which overlies the volcanic plains. The Amenthes region appears to have been affected by moderate to strong winds that imply the presence of large sand dunes.

Old telescopic observations demonstrated that this region's markings vary rapidly and markedly from a light orange to a smokey gray. A variable whitish spot 100 miles wide, Nix Hesperia, has been seen at times during spring and summer in Amenthes' rough terrain just north of the equator. A large secular darkening was seen during the 1950s in the region, indicating a windswept and scientifically uninteresting landscape.

The mission B spacecraft's lander is scheduled to land near the borders of Cydonia and Mare Acidalium on Sept. 4. The prime site, Cydonia, is located in an area of smooth and rolling plains that are probably covered with aeolian sand and few craters. Some volcanic cones, lava flows and medium sized craters with central peaks have been spotted there. Cydonia is about 9,000 feet below the mean surface. The temperature there may rise as high as freezing; liquid water may be present. This site appears to be geologically and biologically attractive.

Classical telescopic observations recorded seasonal changes and meteorological activity in the region. During the Martian late winter and early spring, the Cydonia site is often covered by arctic haze and a possible extension of the bright polar cap. Later in spring, a dark polar collar covers this latitude. The collar may be caused by strong polar winds that blow from the cold cap, removing the light colored surface layer of dust at the edge of the thaw cap. The dark features have a history of becoming paler in summer and autumn, since they are often veiled by yellow dust.

The landing site lies on the western edge of Cydonia that often becomes brilliantly white. If this whitening is due to the presence of water vapor, not wind-borne dust, the site may be a good place to look for life.

The alternate landing site for Mission B, launched in September 1975, is Alba (Latin for white garment), located on a large volcanic shield. This classic feature, so named because of its often bright, white appearance, is a broad, dome shaped planetary feature over 300 miles in diameter. Surrounded by tectonic structures known as fossae, which appear as long, parallel grooves or ditches, the landing site lies on the north edge of the shield 6,500 feet above the mean surface level.

Seen in a telescope, Alba often appears as a white oval in summer due to the formation of clouds on its slopes. These clouds are suspected to be composed of carbon dioxide. Wind velocity in the area depends upon how the observed clouds are formed. If they are continuously created by a standing wave condition, the wind velocity could be high.

This bleak volcanic site doesn't appear promising for the search for life because of its relatively high elevation, low temperatures and possible high winds.

Recent radar studies of the two sites located closest to the equator have placed doubts on their meeting safety standards. A new prime site is being searched for along the equator. The Libya-Isidis basin, located just west of the Tritonis Lacus site, might be the most scientifically interesting area on Mars because of its well recorded history of seasonal activity; it may also be relatively humid.

The basin's steep western slope controls the famous dark triangular shaped Syrtis Major. Equatorial white clouds have been observed here many times during the Martian summer since they were first reported in 1862. According to photographic and spectroscopic observations, these bright white clouds appear when the atmospheric water vapor content is greatest in the northern hemisphere. They tend to form on the southern and western slopes of the basin and sometimes cover most of Syrtis Major.

The Isidis or northern part of the basin floor is often covered with brilliant white patches presumedly composed of frost or fog. These spots show little movement but vary in size and brightness from day to day. Strong winter winds are indicated in this area because dust or sand is deposited from the basin onto the eastern slope of Syrtis Major. The summer climate is probably mild, since the area appears to be stable during this season.

The floor of the Libya-Isidis basin is approximately 9,000 feet below the mean surface level and seems to be covered by wind-driven sand deposits with a moderate abundance of small craters. During the summer, observations suggest it may have relatively high temperature and humidity levels as well as enjoying calm afternoons. If there are no large sand dunes or thick layers of dust present, one of the Vikings may land there.

The age old question of whether there is terrestrial-like life on Mars might be answered soon after the Vikings land on the Martian surface. A negative response in the biological equipment will not be the final answer to the question, though. "The right answer," Gerald Soffen, Viking project scientist, said at a recent news conference, "is the crucial answer, not the first answer."

---

# CORRECTION

*Editors' Note: In the April 1976 story, "Pioneer Passes Saturn," it was mistakenly reported that Pioneer 10 will pass the vicinity of Proxima Centauri. This is incorrect; the spacecraft will travel the distance to Earth's second nearest star, but will not approach the star at all.*

# BRIEFS

● The nearly global Martian dust storm that greeted the Mariner 9 spacecraft in November 1971 may have been caused by the same processes that raise enormous dust clouds in three terrestrial locations. Two Jet Propulsion Laboratory scientists report mechanistic links between the 30+ mile high dust storm that swept across the planet's surface at speeds in excess of 300 m.p.h., and somewhat tamer dust storms on the Russian steppes, the high plains east of the Rocky Mountains and the mountain-ringed valleys of Iran.

● The presence of heavy elements on the surfaces of some stars has puzzled stellar evolutionists for years. Theories on the internal processes of stars cannot account for the presence of promethium and europium (among others) on stellar surfaces. Until now, no one has satisfactorily suggested what mechanism is responsible.

A Russian mathematician and a Polish scientist believe neutron stars are the culprits. They suggest that instabilities in neutron stars, whose interiors are regarded by some theorists as supercolossal nuclei rich in neutrons, would eject extremely heavy nuclei from envelopes surrounding the star. The exiled nuclei, with atomic numbers of 161 to 184, would form superheavy as well as known heavy elements that eventually would find their way to the surfaces of nearby "normal" stars.

● During its December 1973 encounter with the solar system's largest planet, Pioneer 10 obtained two distant, low resolution photographs of Jupiter's largest moon, Ganymede. Craterlike and marelike features, as well as bright areas possibly corresponding to ice fields, appeared in the photographs taken in the red and blue portions of the visible light spectrum. Earth based spectroscopic observations have established that Ganymede has a rocky surface partially covered with ice.

● Three of the four gas giants, Jupiter, Saturn and Neptune, radiate more heat than they receive from the sun due to a combination of residual heat from their formation 4.5 billion years ago and a probably very slow gravitational contraction rate. The fourth planet of the group, Uranus, had its temperature taken by five astronomers recently. The low measurement (-360 degrees Fahrenheit) indicates cold Uranus may have a slower contraction rate, though the cause for this is unclear.

## *Distance to Puzzling BL Lac Galaxy Obtained*

Astronomers at the Anglo-Australian Observatory have measured the distance to one of the BL Lacertae galaxies, a rather puzzling class of celestial objects.

Considered similar to quasars and Seyfert galaxies in that BL Lac objects radiate significant and variable amounts of nonthermal energy, the recent observations made with the observatory's 151 inch telescope at Siding Spring, Australia remove a major barrier toward the understanding of BL Lacertids.

Spectra previously obtained of BL Lac nuclei disclosed no obvious absorption or emission lines. Absorption lines of sodium, calcium and other elements were detected in the surrounding "fuzz" or halo of PKS 0548-322, a member of the BL Lac class. Spectral measurements yielded a redshift of 0.07 for PKS 0548-322, placing the object 350 megaparsecs from Earth (about 400 times as far as the Andromeda galaxy, Earth's closest major galaxy). PKS 0548-322 has a luminosity equivalent to that of a bright elliptical galaxy.

How BL Lacs — formally known as compact nonthermal objects — generate variable energy levels is still unknown, although this distance measurement allows theorists to model energy generation mechanisms that may eventually lead to BL Lacs being placed in an evolutionary sequence with Seyferts and quasars. Because the observed object was found to contain two zones with dissimilar redshifts, the controversy over the true distance of these galaxies will, no doubt, continue.

---

## Pulsar Finding Machine Aids Astronomical Search

Pulsars, the celestial oddities uncovered by radio technology, are being vigorously sought by two astronomers with the aid of a pulsar finding machine (PFM).

Russell Hulse and Joseph Taylor of the University of Massachusetts estimate that the incorporation of their automated device allows them to search for these regularly pulsing stellar objects with equipment 20 times more sensitive than any previous effort.

The sensitivity of the two scientists' search is due to the 20 acre collecting dish at Arecibo, Puerto Rico, and their PFM — which includes a filter-type receiver interfaced directly to a small computer.

Since their search began in 1974, the two astronomers have discovered 40 pulsars. Their most interesting discovery is PSR 1913+16, a pulsar observed in a binary system.

"Our earliest observations of PSR 1913+16 (in July 1974) showed a tremendous change in the period of the pulse from day to day," Hulse recalled. "This pulsar's pulse seemed to vary more in five minutes than most known pulsars changed in a year." The two scientists later attributed these extraordinary changes to a Doppler effect caused by the pulsar's orbital motion about its unseen companion.

To date, Hulse and Taylor have been able to calculate limits for the masses of the objects in this binary system. They concluded that the companion star must be rather massive to affect the pulsar's orbit so strongly, but it also must be small.

"If the pulsar's companion were an average main sequence star," Taylor said, "it would eclipse the pulsar periodically because of the proximity of their orbits. But we don't see any eclipses." The most likely explanation, he said, is that the companion star must be very compact — either a white dwarf, another pulsar or a black hole. If positively identified as a black hole, the dark companion would make this binary a doubly remarkable discovery.

"If the other object is also a pulsar," Hulse said, "then its radiation is either not beamed in our direction or (is) too weak to be observed at this distance."

The third possible identification for the pulsar's companion — the white dwarf hypothesis — would also mean that the compact object had exhausted its nuclear fuel and condensed to a fraction of its former diameter. There is, however, little excitement attached to the discovery of another white dwarf.

Already, the binary pulsar has become a kind of space laboratory for testing classical and modern theories of gravitation. To check out these theories, Hulse and Taylor must determine the masses of both objects and then compare the observed behavior of the stars to theoretical predictions.

"Each of these theories," Taylor explained, "makes certain predictions about the way these orbits should behave." Another five years of observations may yield a full description of the orbits and good evidence for one of the three competing theories.

# Lunar Transmitting Station Fails; Scientists Puzzled

Strange things are happening on the lunar surface.

Last January, one of the five remote scientific stations transmitting lunar data "died". Johnson Space Center (JSC) scientists were puzzled, since the station — one of five established by earlier Apollo missions — was expected to continue functioning for another two or three years. Although the station's receiver failed in March 1975, making the station immune to any ground control orders, there were no indications that it was headed the way of the passenger pigeon and dodo.

Unexpectedly, the station began functioning again on Feb. 19. In fact, it was performing better than ever: One of the experiments that had never operated during the high heat of the long lunar day now functioned flawlessly.

Then, inexplicably, the station shut down again one month later.

A NASA spokesman, Charles Redmond, said the unexpected performance of the station, known as ALSEP (Apollo Lunar Scientific Experiment Package), might be related to the extreme temperature changes on the moon. The station had stopped performing near the lunar "noon" and had returned to life close to the lunar "midnight". Temperatures on the moon range from 250 degrees Fahrenheit to less than -300 degrees Fahrenheit.

JSC engineers and scientists were expecting the station to turn on again around April 19, but it did not come back on. "It's kind of disheartening," Redmond said. "We hoped the (station's) signal would return when the station cooled down."

None of the four other ALSEPs have performed this way. "It was unique in the way it quit, in the way it came on and the way it cycled," Redmond said. Engineers are groping for another theory to explain the station's behavior. The latest idea suggests that the station's radio-isotope thermal generator, located near the nuclear power pack, cools down and heats up, affecting ALSEP's performance.

Established by Alan Shepard and Edgar Mitchell during the 1971 Apollo 14 mission, the erratic performance of ALSEP has some outside observers wondering if there isn't some "mysterious force" controlling the station — although JSC scientists dismiss this possibility as "nonsense".

An additional problem adds to ALSEP's mystique: An experiment using a mortar-fired shell to generate shock waves for the station's seismometers has been put off until the station's expected death, if it will be conducted at all. Confidence in the experiment has gone down since ALSEP's behavior problems began. One source confessed it "probably won't ever be set off because of reliability problems."

What makes the experiment interesting, however, is the fact that three mortars have been fired already, but the launcher's position was so changed by the firings that the fourth mortar is no longer aimed in its intended direction. Instrument readings, JSC scientists hope, are incorrect, because all indications show the mortar now points at ALSEP's central transmitting and power station.

ASTRO-MART
only in ASTRONOMY

# "Animal" Spotted In Solar System

Depending upon your viewpoint, the solar system either has nine planets or eight planets and one animal.

The "animal" in question, as you might have guessed, is Jupiter. Along its way out of the solar system, Pioneer 10 detected a 430 million mile long magnetic tail trailing behind the Jovian planet. Jupiter's tail stretches intact past Saturn's orbit, which means the ringed planet passes through Jupiter's extremity once every 20 years.

Jupiter's tail is actually a magnetic envelope stretched out by the force of the one million mile per hour solar wind.

Actually, two planets have tails — the same two planets that possess strong magnetic fields: Jupiter and Earth. Earth's tail is shorter than Jupiter's by 426 million miles. Both tails are believed to be shaped like cometary tails, since both types result from solar processes.

# *Pulsars Streak Through Space*

Radio astronomers at the University of Massachusetts have discovered that pulsars are rapidly moving space travelers. The astronomers, led by G. Richard Huguenin, report that the pulsars move through space at speeds of up to 1.25 million m.p.h.

Twelve pulsars were observed by the team streaking through space at velocities ranging from 30 to 350 miles per second. At the latter speed, pulsars can escape the gravitational attraction of the Milky Way. By comparison, Earth crawls around the sun at the miserly rate of 18.5 miles per second.

Theorists suggest that pulsars might act like photon rockets to propel themselves at such rates. Accelerated by the electromagnetic energy the pulsar emits — in the form of light or radio waves — the propelling force results from a slight displacement of the intense magnetic field at the collapsed star's center. The pulsar moves in the opposite direction of the displacement. Velocities of more than 1,000 miles per second — or over 3.6 million m.p.h. — could be produced in this manner.

---

# Solar Dispute. Ranks Grow

Another scientist has joined the solar variability fray. D. W. Parkin, a physicist at the University of Bath in Bristol, England, has suggested that the sun's luminosity has varied five percent every 100,000 years.

Parkin studied possible causes of the recent series of ice ages. He said the Milankovitch model, the accepted explanation of variations in climate, is unacceptable because it "cannot cause the major glacial cycles." It may be responsible for minor fluctuations during times of major climatic variation, he said, but it doesn't satisfactorily account for observed climatic cycles.

The Milankovitch model states that climate periodicity is caused by slight changes in Earth's axial tilt and orbit. It doesn't allow for variations in the energy generation mechanism at the sun's core. (See "New Evidence Obtained For Discarded Solar Theory," May 1976, and "Solar Pulsations Detected; Throws Kink in Theories," April 1976.)

**A CALENDAR FOR EVERYONE**

**EQUITABLE CALENDAR**

**by Fr. Evarist Kleszcz**

***Simplified — Fixed — Perpetual — Ecumenical***

**A reform which does not break radically from our present calendar.**

***$1.50 — 32 pages***

**FRANCISCAN FRIARS OF MARYTOWN**

8000 39th Avenue, Dept. AM,
Kenosha, Wisconsin 53141

**CELESTRON DEMONSTRATIONS**

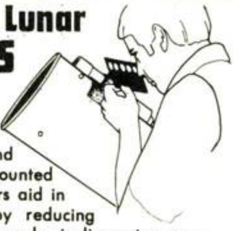
**UNDER NIGHT (OR DAY) SKIES**

Find out for yourself what others see in and through the orange tubes. See how the Celestron system is designed to provide you with just the right accessories for your visual and photographic needs. C5, C8, Binoculars and accessories in stock.

**David A. Potter**
**723 Cedar Dept. A, Sandwich, IL 60548**
**(815) 786-8168**

**Dealer: Celestron Telescopes & Accessories**

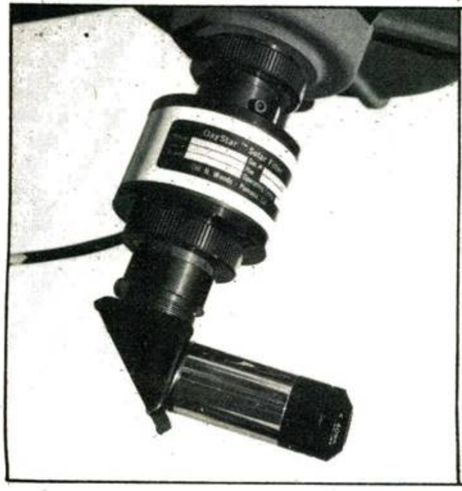
**Planetary & Lunar FILTERS**



**Five widely used precision color filters so essential to serious planetary and lunar observers mounted in sturdy card. Filters aid in observing details by reducing glare, minimizing atmospheric dispersion, penetration of planets atmosphere, increasing color contrast, and reducing irradiation. Wratten numbers; 21-orange, 25-red, 38A-light blue, 47-violet, 58-green. Includes instructions. A must at all telescopes**

**7.50 Ppd.**

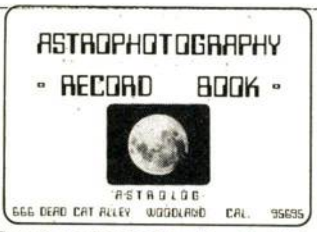
**Send Check or Money Order to:**
**FT. WAYNE ASTRONOMICAL SOCIETY INC.**
**P.O. Box 6004 Ft. Wayne, Indiana 46806**



WANTED — Field investigator for new UFO research organization. Contact either Dan Corjulo, 172 Stoner Dr., West Hartford, CT 06107, or Mark Winslow, 7326 E. Connecticut, Tulsa, OK 74133.

WANTED — 30mm-40mm 1-1/4" O.D. eyepiece; state type. Also optical system for, or complete, f/4-f/5 4-1/4" RFT. Write Joe Dal Santo, 269 Brashares, Addison, IL 60101.

WANTED — Donations of ASTRONOMY back issues, other science magazines and science texts for use in high school science classes. Acknowledgement of donation will be made for tax purposes. Write William Dunkum, T.C. Williams High School, 3330 King St., Alexandria, VA 22302.



**Concise organized log for tabulating all pertinent astrophoto exposure data.**

- Dew resistant pages
- Comb bound
- 360° swing open bindings
- Rigid covers for writing stability

**$4.25** (incl. shipping)
Outside U.S. add $1.00 CA add 6% tax

**ASTROLOG**

**666 Dead Cat Alley, Woodland, CA 95695**

**This Quarter Of The Universe Is OURS!**

*(A Handbook For Building Three Dimensional Starmaps)*

Includes computer coordinate translations of the entire Gliese **Near Star Catalogue** of 2,000 stars to 3D mode (X,Y,Z and top view Polar) in unit parsecs scale; 3D coordinate list for stars within 6 parsecs at 3"/pc **and** unit parsec scale; 6 parsec exterior front view key; complete instructions and diagrams for building a beautiful 3 foot 3D map of the 80+ nearest stars within 6 parsecs; 3D list of the approx. 500 nearby stars with absolute magnitude of 6 or less; the working computer program; general advice in starmap design. This exceptional book is the result of 5 years work. $6 US ppd.

ORDER FROM:

**THETA ENTERPRISES,**
**114 N. McKinney, Dept. AM,**
**Richardson, TX 75080**

***DayStar Filters***

***Hydrogen Alpha**
***Calcium K-line**
***Corona filters**
***Laser line filters**
***Half-bandwidths:**
***0.4 Å to 100 Å***
***Wavelength range:**
***3700 Å thru 2.5 u***

**DEL N. WOODS**
P.O. Box 1290, Dept. AM,
Pomona, CA. 91766
Phone: 714/629-0600 (N.Y.) 914/786-3738

## ASTRO-MART

*continued from page 58*

WANTED — Persons to join Society for Purposeful Achievements in Cosmological Exploration. Purpose is to help space program. Write Ed Bernstein, c/o S.P.A.C.E., 39 Birch St., Lynbrook, NY 11563.

WANTED — Celestron 14 or Celestron 14 optical tube assembly with special coatings group. Also PLS camera by DOAA. Contact R. Cain, c/o Railmark Ltd., 17 Barstow Rd., Great Neck, NY 11021. Phone (212) 895-7498.

WANTED — Illuminated reticle and short focus orthoscopic or Erfle eyepieces (1-1/4"); equatorial mount with clock drive for 6" reflector. Refractor with equatorial mount, slow motion controls suitable for astrophotography (without camera). Contact Ranes C. Chakravorty, Veterans Administration Hospital, Salem, VA 24153. Phone (703) 981-0316.

WANTED — Persons interested in starting astronomy club in Valdosta area. Also persons interested in joining local "Star Trek" club (VISTAS). Contact Tim Farley, 3001 Wendover Rd., Valdosta, GA 31601. Phone (912) 244-4075 after 5:30 p.m.

WANTED — Complete Celestron 8 in excellent condition. Send full details to James M. George, 3020 Geronimo Rd., Prescott, AZ 86301.

WANTED — Correspondence from persons interested in astronomy and/or astrophotography. Write Larry Hanbrook, 7837 Keystone, Skokie, IL 60076.

WANTED — Correspondence with anyone interested in astronomy and/or astrophotography. Write Jorge H. Jaime, 1101 E. Sam Houston, Pharr, TX 78577.

WANTED — Stamps related to space, astronomy, etc. Other general postage stamps also considered. Write O. Douglas Johnson, M.D., 7205 Bellrose Ct. N.E., Albuquerque, NM 87110.

WANTED — Back issues of ASTRONOMY: August 1973 through October 1975. Will pay $50.00 for complete set in good condition. Write Jack Kennedy, 40-A Schumaker Ln., Salisbury, MD 21801.

WANTED — Old IAU circulars (prior to 1975). Also information on available catalogs/publications concerning orbits of asteroids. Write Gary W. Kronk, R.R. #4, Box 149, Edwardsville, IL 62025.

WANTED — Observational results (written descriptions, drawings, photos) from Criterion Dynascope owners. Write Jeff Linstrom, 1526 Saunders Dr., Wooster, OH 44691.

WANTED — Complete set of ASTRONOMY magazines in good condition. Also any books, magazines on black holes and cosmology. Send lists and prices to Wayne Lypka, 189 Centre St., Flin Flon, Manitoba, CANADA R8A 0G1.

WANTED — Correspondence with persons interested in exchanging ideas and hints on stargazing with binoculars. Also ideas for building binocular stand. Write Tom McKinney, Rt. 2 (44 Deer Trail), Prescott, AZ 86301.

WANTED — Plans for construction and operation of a radio telescope, spectroheliograph, or other instruments for science fair project for high school freshman. Write Steven Mango, 88 Trenton St., East Boston, MA 02128.

WANTED — Celestron 14. State price, condition, accessories. Contact Rex Price, P.O. Box 893, Grand Junction, CO 81501. Phone (303) 245-4800.

WANTED — Planetarium projector or star ball from same. Any manufacturer, model, age or condition. Will trade, rent or buy. Contact Frederick Ream, 61 Baird Ave., Lewiston, ME 04240. Phone (207) 782-0852.

WANTED — Hurst C.A. or D.A. motor, synchronized, 1 r.p.m., 100 oz. inches of torque. Also declination slow motion control for Edmund heavy duty mount with 1" shaft, 1-5/8" declination shaft housing; manual or powered. Write Norm Schklair, 1834 Cavalier Dr., Tempe, AZ 85281.

WANTED — Celestron 14 or transportable 12-1/2" Cassegrain (not Dall-Kirkham). Reasonably priced. Write Bob Somerville, 11692-215th St., Maple Ridge, British Columbia, CANADA V2X 5G7.

WANTED — Quality Caustic or Dall Null Test with compensator lens. Write Bob Somerville, 11692-215th St., Maple Ridge, British Columbia, CANADA V2X 5G7.

WANTED — Any early Nikkor lenses that will fit the early model Nikon S2 viewfinder camera; preferably telephoto lenses. Contact Scott Sondey, 2235 Briar Patch Ln. Hatfield, PA 19440. Phone (215) 368-6582.

WANTED — December 1974 issue of ASTRONOMY. Must be in good condition. Will pay any reasonable price. Write John Spicer, 42 Crescent Dr., Wellsville, NY 14895.

WANTED — "Jupiter: Encounter With A Giant", and other NASA books. Also slides on space, science fiction. Contact Max Spielberg, 16 Stiles St., Elizabeth, NJ 07208. Phone (201) 353-0532.

WANTED — Astronomical art of all kinds: pictures, slides, calendars, etc. Also binders for ASTRONOMY magazines. Write M. Spielberg, 16 Stiles St., Elizabeth, NJ 07208.

WANTED — Back issues of ASTRONOMY: September 1973 through February 1974; May, August, December 1974. Will pay any reasonable price. Write Nicky Szluk, 944 Kings Highway, Lincoln Park, MI 48146.

WANTED — Any comet photos, information, plotting, location of interested groups, etc. Needed for publishing book. Write Raymond Tawyea, 4414 First Ave., Hibbing, MN 55746.

WANTED — May 1974 issue of ASTRONOMY. Must be in excellent condition. Will pay up to $10.00. Contact Murray Wilson, 4216 Nelson Rd., Middletown, OH 45042. Phone (513) 423-0296.

INFORMATION WANTED — On how to find nebulae. Also information on extraterrestrial life and UFOs. Write Clay Mitchell, Kentmore Park, Kennedyville, MD 21645.

# ASTRONOMY
## Guide to Back Issues

Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly; issues not listed are depleted.

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

***$1.50** per copy*
***U.S. — Add $1.00 per order***
***Canada/Mexico — Add $2.00 per order***
***All Other Foreign — Add $2.50 per order***

| | | | |
|---|---|---|---|
| **Vol. 1, No. 1 - August 1973** | **Available** | **Vol. 3, No. 7 - July 1975** | **Available** |
| **Vol. 2, No. 3 - March 1974** | **Short Supply** | **Vol. 3, No. 8 - August 1975** | **Available** |
| **Vol. 2, No. 4 - April 1974** | **Depleted** | **Vol. 3, No. 9 - September 1975** | **Available** |
| **Vol. 2, No. 6 - June 1974** | **Short Supply** | **Vol. 3, No. 10 - October 1975** | **Available** |
| **Vol. 2, No. 7 - July 1974** | **Short Supply** | **Vol. 3, No. 11 - November 1975** | **Available** |
| **Vol. 2, No. 9 - September 1974** | **Short Supply** | **Vol. 3, No. 12 - December 1975** | **Available** |
| **Vol. 2, No. 10 - October 1974** | **Short Supply** | **Vol. 4, No. 1 - January 1976** | **Depleted** |
| **Vol. 2, No. 11 - November 1974** | **Short supply** | **Vol. 4, No. 2 - February 1976** | **Available** |
| **Vol. 3, No. 1 - January 1975** | **Short Supply** | **Vol. 4, No. 3 - March 1976** | **Available** |
| **Vol. 3, No. 2 - February 1975** | **Depleted** | **Vol. 4, No. 4 - April 1976** | **Available** |
| **Vol. 3, No. 5 - May 1975** | **Available** | **Vol. 4, No. 5 - May 1976** | **Available** |
| **Vol. 3, No. 6 - June 1975** | **Available** | **Vol. 4, No. 6 - June 1976** | **Available** |
| | | **Vol. 4, No. 7 - July 1976** | ***NYP** |

*** Not Yet Published**

**Please allow at least four (4) weeks for delivery.**
Rosemary L. Pickart,
ASTRONOMY Magazine
757 N. Broadway, Suite 204
Milwaukee, WI 53202
(414) 276-2689

# STAR DOME

# JUNE

by
James Mullaney and Henry J. Phillips

Everyone has heard of "long, lazy summer days" that seem to go on forever. While these may be very enjoyable, the astronomer must be concerned with their corollary: short, hectic summer nights that aren't nearly long enough. Some observers may find themselves hard-pressed to squeeze in all the objects they wish to view during a night of only a few hours' duration. Particularly in the northern sections of the continent — in Canada and southern Alaska — the sky is completely dark only from about 11:30 p.m. to 3:00 a.m., and above the Arctic circle the sun never sets at this time of year. As the sun reaches the summer solstice (the north point of the ecliptic) on June 21, it stays in the sky longer in our latitudes than during any other month.

Once the sun sets, the first star most people will view — mainly because it's the first star to appear through evening twilight — is Arcturus, brightest star in the constellation Bootes the herdsman and the fourth brightest star in the sky. In fact, from most of North America, Arcturus is second only to Sirius, since Canopus and Alpha Centauri don't rise above the southern horizon. Also, Arcturus is the brightest star in the sky's northern hemisphere; its magnitude is -0.06, and the star has an unmistakable orange color.

Arcturus has always been one of the best known and most important stars to many different nations. It has generally been associated with nearby Ursa Major, the great bear. In translations of several ancient texts, the two have been confused — probably because of the similarity of the name "Arcturus" the Greek word *arktos* (bear). For example, there is a supposed reference to the star in the Book of Job, but more correct translations of the original Hebrew show that the writer actually refers to the great bear.

In old drawings of the entire constellation, the star has represented various parts of the herdsman's body. It has been one of the knees, the chest, a clenched fist, or a weapon held in the herdsman's hand. But to the ancients — perhaps because of the star's brightness and importance — it marked the genitals. Discreet 17th century mapmakers preferred to place the star on the hem of the man's tunic.

Depending on the civilization, Arcturus has been a lucky or an unlucky star. According to Hippocrates, diseases were likely to become critical during the time of its rising, and the Romans associated it with stormy weather. The Arabs, on the other hand, had a charming picture of the star as a shepherd watching over his flocks — which are all the other stars.

This last image most closely matches our current name for the constellation Bootes as a whole: the herdsman. Most drawings show him with an upraised staff in one hand, and perhaps a scythe in

# History of American Astronomy

## July 1976 Special Bicentennial Issue From ASTRONOMY

**The July 1976 issue of ASTRONOMY will be entirely devoted to the history of astronomy in the United States. While focusing on the two centuries of America's history as a nation — from the signing of the Declaration of Independence through today — this unique issue will also explore the astronomy practiced by, and skylore of, indigenous Americans who greeted the earliest colonists.**

**A collectors' item published with the hallmarks of quality and excellence ASTRONOMY is noted for, this unprecedented work has reached national importance even before publication and will be featured on national television in the near future.**

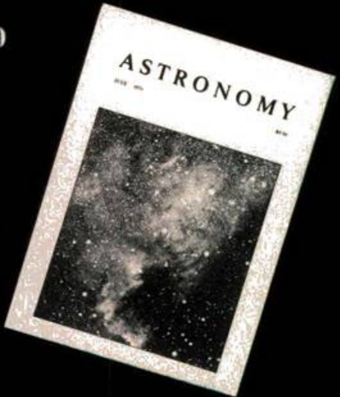
**Authors for the July 1976 issue include Von Del Chamberlain, Henry J. Phillips, Michael Mendillo, Richard Berendzen and David DeVorkin.**

**Due to its importance, increased size (at least 96 pages instead of the usual 80), and the greater cost of producing it, this special July issue will bear a single copy cover price of $3.50 each.**

**As a regular paid subscriber, however, you will receive this bicentennial offering as the first copy of your normal 12 issue, $12 subscription. You'll save $8 from the cost of single copies.**

**—American Bicentennial Subscription Offer—**

**Single Copies: $3.50**

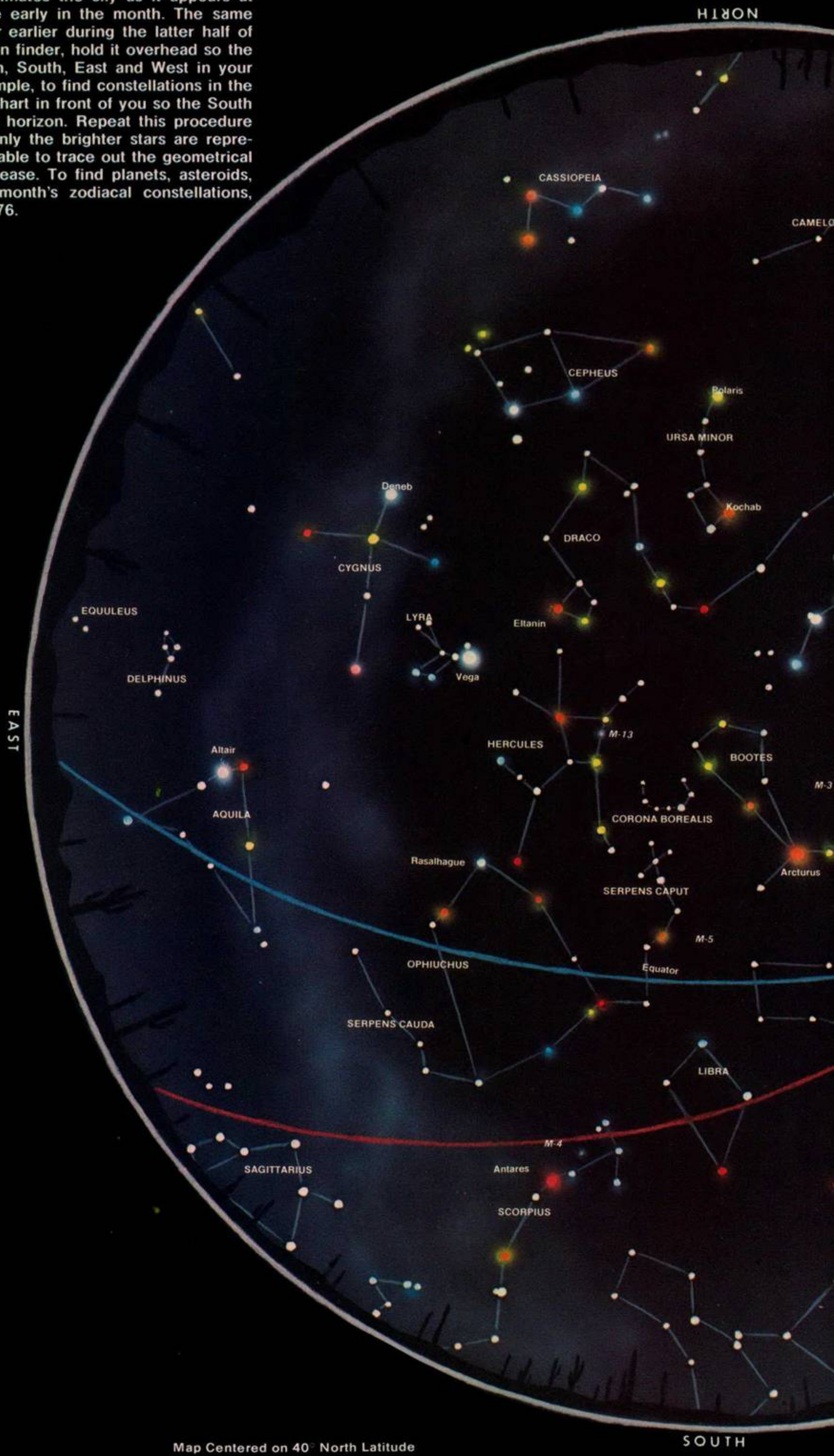

ASTRONOMY

**1 Year, 12 issues including July 1976 — $12**
**2 Years, 24 issues including July 1976 — $22**

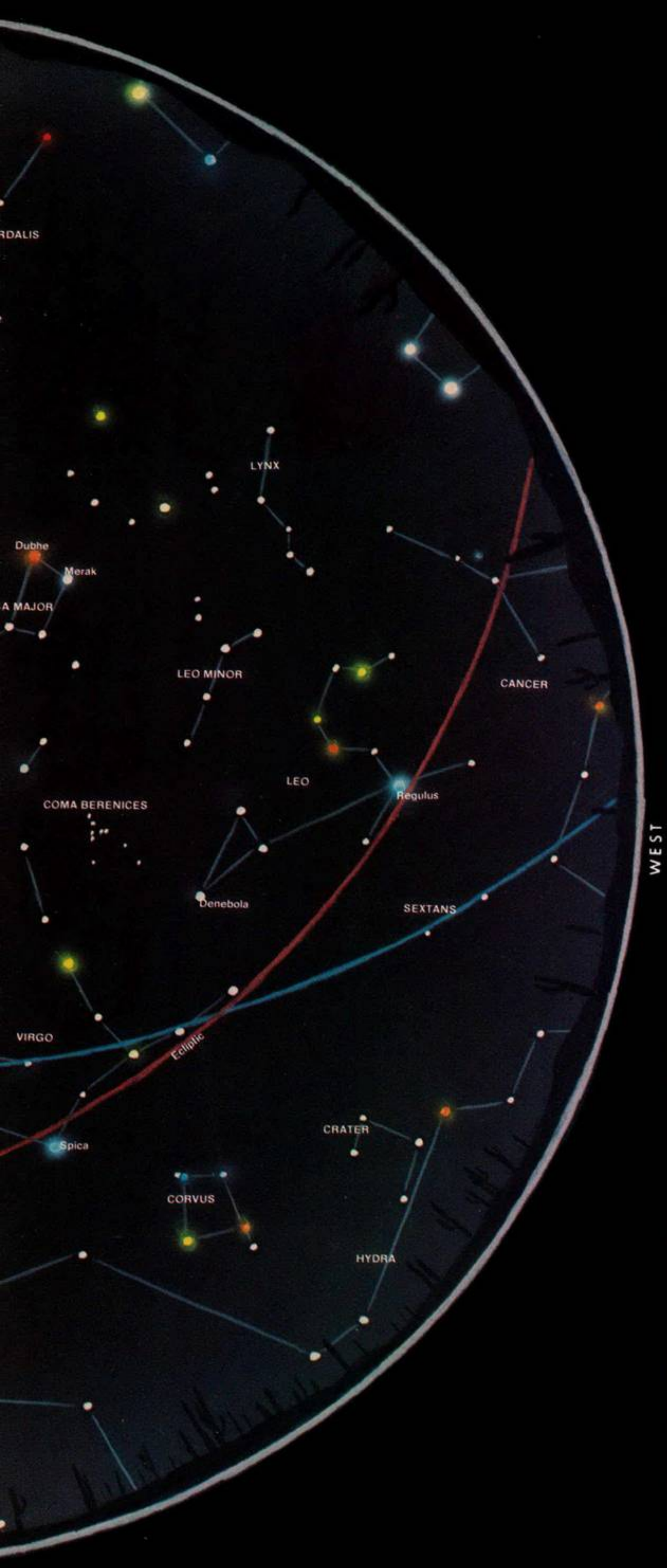
**ASTRONOMY 757 N. Broadway Suite 204, Milwaukee, WI 53202**

**Bicentennial Subscription Offer Good Till December 31, 1976**

**This Star Dome rendering approximates the sky as it appears at about 11:30pm Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.**


NORTH
CASSIOPEIA
CAMELO
CEPHEUS
Polaris
URSA MINOR
Kochab
Deneb
DRACO
CYGNUS
EQUULEUS
LYRA
Eltanin
Vega
DELPHINUS
EAST
M-13
HERCULES
BOOTES
M-3
Altair
AQUILA
CORONA BOREALIS
Rasalhague
Arcturus
SERPENS CAPUT
M-5
OPHIUCHUS
Equator
SERPENS CAUDA
LIBRA
M-4
SAGITTARIUS
Antares
SCORPIUS
SOUTH

Map Centered on 40° North Latitude



Map by Adolf Schaller

the other. The constellation has also been known as a hunter holding two dogs (Canes Venatici) on a leash and annually pursuing the great bear around the pole. An Arabian name for the constellation, Al Hamil Luzz, means the spearbearer. Bootes may have received its present title from the Latin *bos*, meaning oxen — making Bootes a cowkeeper as well as a shepherd. No significant mythological figure is pictured in Bootes — the constellation matching Auriga the charioteer in this regard.

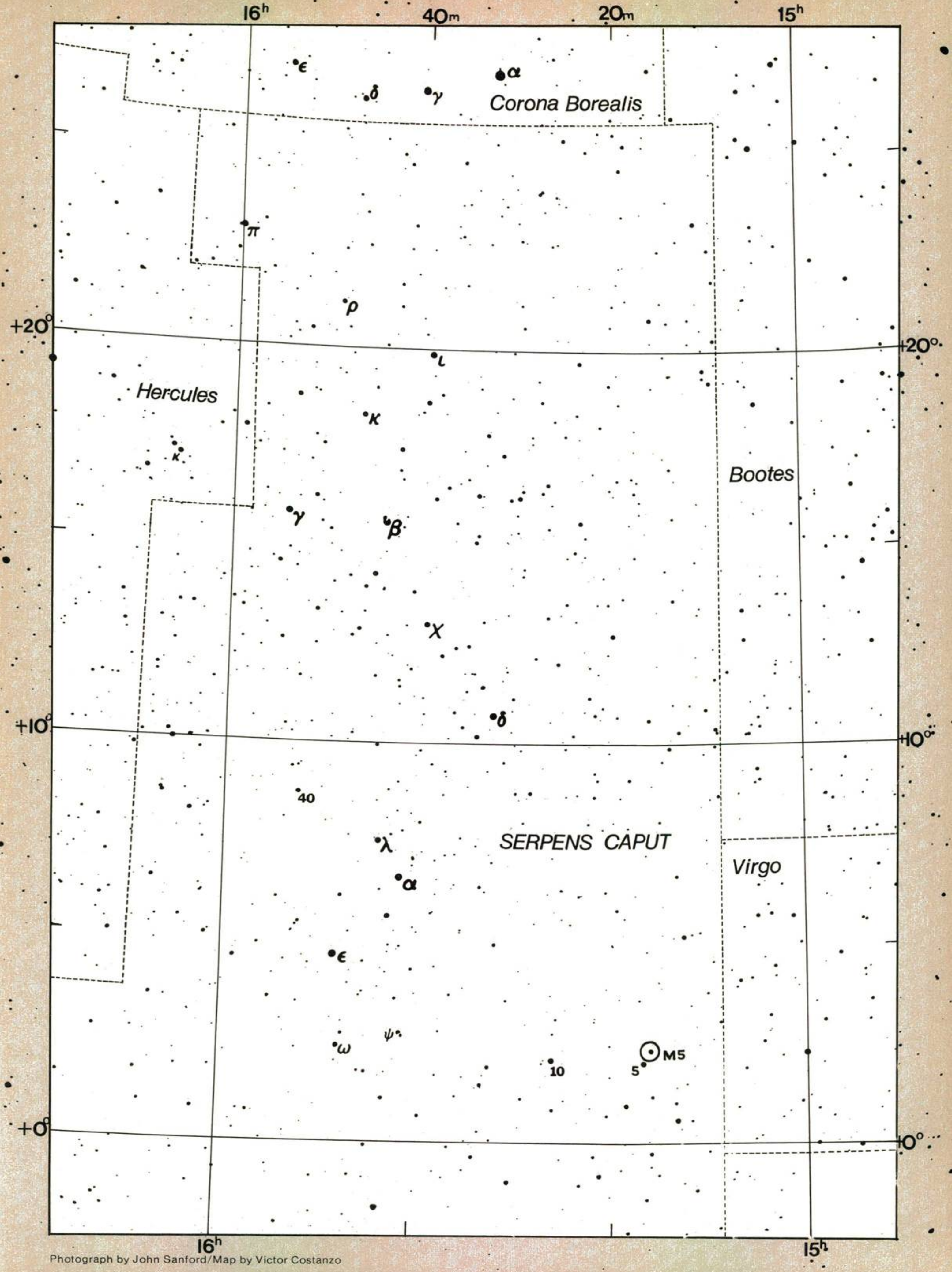
The star Epsilon Bootis, one of the brighter stars in the group, has the official name of Izar from the Arabic "girdle" that this star marked in old drawings. Another name, however, was given this star by Otto Struve: Pulcherrima, or the most beautiful — a reference to the star's stunning appearance through the telescope. Epsilon is a gorgeous binary, the two stars being yellow and blue-green and providing one of the most beautiful color contrasts in the entire sky.

Just east of Bootes is a fairly small, delicate semicircle of stars. These make up the constellation Corona Borealis, the northern crown. This group was once known simply as Corona, but the adjective had to be applied when the southern crown was placed in the sky near Sagittarius.

In Greek mythology, Corona Borealis represents the crown given to the princess Ariadne by the god Dionysus, who fell in love with her after she was jilted by the hero Theseus and abandoned on the island of Naxos. An alternate version of the tale states that the constellation is Ariadne herself, placed in the sky by Dionysus after her death. The constellation has been a popular one, and was mentioned by Dante and Chaucer. Some have depicted the crown as a simple wreath of flowers; to others, it was a jewel-studded diadem. The Arabs, however, knew Corona Borealis as the dish or the pauper's bowl — a conceit that survives today in the name of Corona's brightest star: Alphecca, the bright one of the dish. Another — and better known — name for the star is Gemma, referring either to the largest bud in the crown of flowers, or the most glittering stone in the golden crown.

Corona Borealis has, in fact, represented a crown to all but a few peoples. Among these exceptions are the Chinese, who depicted a cord of rope in these stars, and the Celtic races, to whom the group was Ethlenn, daughter of the Fairy King.

Near the eastern edge of the crown is one of the most interesting stars in the heavens. Known as T Coronae Borealis, this is one of the few stars which has exploded more than once. In 1866, this formerly nondescript, 10th magnitude star suddenly shot up in brightness to second magnitude, and then slowly declined to its accustomed dimness. Astronomers gave no more thought to it until 1946, when the star suddenly went nova a second time! It again reached second magnitude before fading, and many observers today keep a close watch on the star in


16h
40m
20m
15h
ε
α
δ
γ
Corona Borealis
π
ρ
+20°
ι
+20°
Hercules
κ
κ
Bootes
γ
β
χ
δ
+10°
+10°
40
λ
SERPENS CAPUT
α
Virgo
ε
ψ
ω
M5
10
5
+0°
+0°
16h
15h

Photograph by John Sanford/Map by Victor Costanzo hopes that it will exhibit further peculiar behavior.

Crossing the meridian much farther south on June evenings is an oddity among star groups: a constellation that was formerly a section of another and was made separate in historical times. This is Libra the scales; the curiosity of its late formation is deepened by its presence in the zodiac — in which, significantly, Libra is the only inanimate object.

At one time Libra formed the claws of neighboring Scorpius the scorpion, and the two formed a sort of double sign in the zodiac. Even at this time it was a semi-independent group, for the Greeks called it Chelae (claws). It was not definitively detached from the scorpion until Roman times. Its opposite neighbor in the zodiac is Virgo the virgin, and the scales were said to belong to her in her personification of Astraea, goddess of justice.

Since the Latin days, the constellation has been universally known as the scales, or the balance. Yet the names of its principal stars still refer to its old identification as the pincers of the scorpion. Alpha Librae has the tongue-twisting title of Zubenelgenubi (the southern claw), while Beta's name is Zubeneschemali (the northern claw). The stars are also called Kiffa Borealis and Kiffa Australis; these names are the Latin versions of the other titles and have the same meanings.

Beta Librae is unusual in that nearly every one of the classic observers said it had a rich emerald green color. Many of those who see the star today agree; others, though, insist that the star is no more than a typical blue star. Try it yourself: What color can you detect through your binoculars or telescope?

Between Libra and Corona Borealis is yet another oddity — a half-constellation. This is Serpens Caput, the head of the serpent, separated from its tail (Serpens Cauda) by Ophiuchus. The two groups together are said to form the single constellation Serpens, the only one of our star groups to be separated into two parts. Probably Ophiuchus and Serpens were once a single huge constellation, later divided for unknown reasons.

Although Ophiuchus, the serpent-bearer, has had many different identifications among various nations, the serpent itself has always been no more than an anonymous snake, writhing in the clutches of its holder. Its lifted head reaches for the northern crown, and in fact, the upraised position of its head might allow us to refer more accurately to Ophiuchus as the snake charmer.

## Close-Up on the Serpens Caput Region

Visible on the southern meridian during June evenings, directly below Corona Borealis, is a sprinkling of stardust that marks the upraised head of the serpent, or (as it is labeled on star charts and atlases) Serpens Caput.

Slow sweeping of this glittering region with 7 x 50 or 10 x 50 binoculars on dark nights is a genuine delight, especially in the vicinity of Beta Serpentis. Near Beta is a seventh magnitude star, and the two form a neat optical double. Just west (right) of Beta is a field full of nearly matched sixth magnitude suns, all of which carry the Greek letter designation of Tau (τ). These are numbered Tau-1 through Tau-8, and together they form a scattered binocular cluster rarely noticed by the casual observer. Barns, in his classic **1001 Celestial Wonders**, dubbed this region a "stellar Golconda" — or, in other words, a region of great richness.

Another interesting binocular object in Serpens Caput is sometimes visible when the stars Beta and Gamma are placed on opposite sides of the same field of view. Nearly midway between them, and just slightly south of the line joining the stars, is the position of the long period variable R Serpentis. When near maximum light at 5.7 magnitude, this red-orange pulsating supergiant lies near naked eye visibility and is obvious in binoculars. However, its minimum is below 14th magnitude, well beyond the reach of most amateur telescopes. With a period of 357 days, the variable's waxing and waning in brightness is extremely gradual. It is quite a thrill to watch stars like R slowly fade from view and disappear, rather like a flickering cosmic ember in the night. It's equally exciting to await the star's return to visibility some months later — but clearly, this is not a project for the impatient!

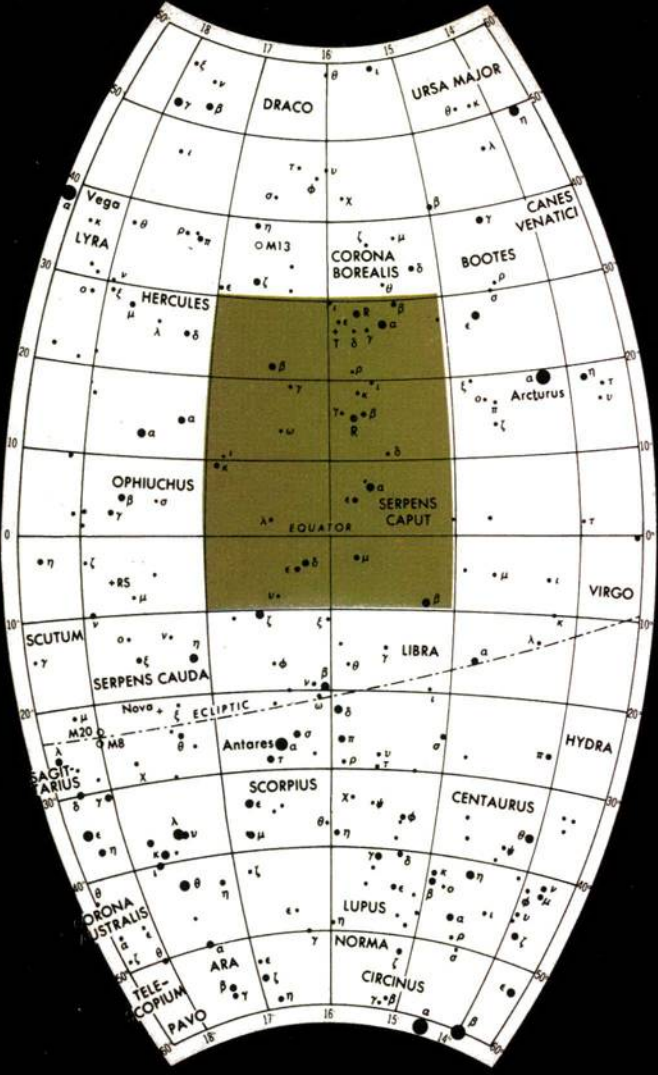
Yet another target for binocular users is the huge globular star cluster known as M-5 (described in detail in Eyepiece Impressions). To find it, locate the stars 109 and 110 Virginis (fourth and fifth magnitudes, respectively). These point due east to the yellow fifth magnitude star 5 Serpentis. Binoculars or a finderscope will show a bright circular patch just northwest of the star.

Many unsuspecting observers, sweeping this area of the sky with binoculars or a telescope, have chanced upon M-5 and experienced the fleeting thrill of having apparently found a bright new comet! The cluster does indeed resemble the head of a comet and definitely seems out of place in such close proximity to a bright star — just as many comets do when they are discovered.

## Eyepiece Impressions

### Delta (δ) Serpentis

This month we offer three different visual doubles for the observer. All are near each other in the sky and yet each has a distinct appeal of its own. Certainly the most striking of this trio for small telescope users is fourth magnitude Delta Serpentis, found just south of the sprinkling of Tau stars mentioned in the Close-Up section.



Map from **Guideposts to the Stars**; reprinted permission of MacMillan Publishing Co.,©1972 by Leslie C. Peltier.

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| α | **Alpha** | η | **Eta** | ν | **Nu** | τ | **Tau** |
| β | **Beta** | θ | **Theta** | ξ | **Xi** | υ | **Upsilon** |
| γ | **Gamma** | ι | **Iota** | ο | **Omicron** | φ | **Phi** |
| δ | **Delta** | κ | **Kappa** | π | **Pi** | χ | **Chi** |
| ε | **Epsilon** | λ | **Lambda** | ρ | **Rho** | ψ | **Psi** |
| ζ | **Zeta** | μ | **Mu** | σ | **Sigma** | ω | **Omega** |

Table of Selected Objects — Serpens Caput Region

| Object | Type | Mag. | Size/Sep. | R.A. (1950) | Dec. |
|---|---|---|---|---|---|
| SERPENS CAUDA | | | | | |
| 2 | ⋆2 | 6.2,7.4 | 0.5" | $14^h59^m$ | +0°03' |
| • M-5 | GC | 6.2 | 13' | $15^h16^m$ | +2°16' |
| • 5 | ⋆2 | 5.2, 10.0 | 11" | $15^h17^m$ | +1°57' |
| • δ(Delta) | ⋆2 | 4.2,5.2 | 4" | $15^h32^m$ | +10°42' |
| • ι (Iota) | ⋆2 | 5.2,5.2 | 0.2" | $15^h39^m$ | +19°50' |
| • β(Beta) | ⋆2 | 3.7,9.2 | 31" | $15^h44^m$ | +15°35' |
| R | V:357$^d$ | 5.7-14.4 | — | $15^h48^m$ | +15°17' |
| 49 | ⋆2 | 7.5,7.6 | 4" | $16^h11^m$ | +13°40' |

• Detailed in Eyepiece Impressions

⋆2,3,4 = Double/Multiple Star
GC = Globular Cluster
V:# d = Variable Star, Period - days
Mag. = Magnitude
Sep. = Separation

A three inch refractor at 90 power discloses a fine specimen of a moderately close pair of unequal brightness consisting of intensely glowing 4.2 and 5.2 magnitude suns nearly touching. As telescope size increases, this object grows increasingly attractive.

Delta appears to be a long period binary system, for changes have been noted in both separation and position angle of the components. For example, in 1842 the companion was 2.8 seconds of arc from the primary and was at position angle 196 degrees. In 1876 these values were 3.5 seconds and 190 degrees; by 1927, they had changed to 3.6 seconds and 181 degrees. Thus the separation is slowly increasing as the position angle decreases. Presently the two stars are four seconds apart and the companion lies near 175 degrees.

Olcott, using a three inch refractor, described this duo as "Both white. A fine object" — and so it is today. Barns adds the brief comment, "strikingly placed".

Most observers see both components as white, but other tints have been recorded. Webb, on one occasion, gave the colors as yellow-white and ashy, and later as white and bluish-white. The companion seems especially difficult to classify, for it has been labeled light gray, orange, greenish-yellow, ashy-yellow and even ashy-olive! Little wonder that observers of the past suspected double stars changed color with time.

The actual spectral type of both stars is F0 (yellowish-white), and the spurious colors reported for the small star are probably a contrast effect resulting from the magnitude difference. Still, virtually no study has been made of double star colors, either visually or photographically. This leaves a fresh field of inquiry for the amateur astronomer.

Delta Serpentis lies some 170 light-years from us, clear of the approaching summer Milky Way.

### Beta (β) Serpentis

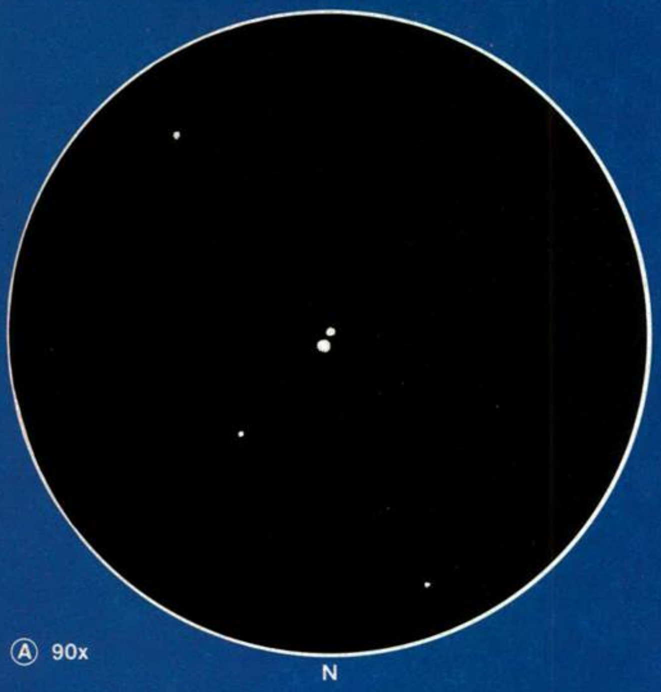
Our second selection offers an example of a magnitude rather than color contrast. This is fourth magnitude Beta Serpentis, brightest of the stars marking the actual head of the serpent.

Generally considered a mild test for a 2.4 inch refractor, the 3.7 magnitude primary has a 9.2 magnitude companion about 30 seconds of arc distant. Although a three or four inch telescope will show the faint star clearly, at least a six inch is needed to appreciate the magnitude contrast effect.

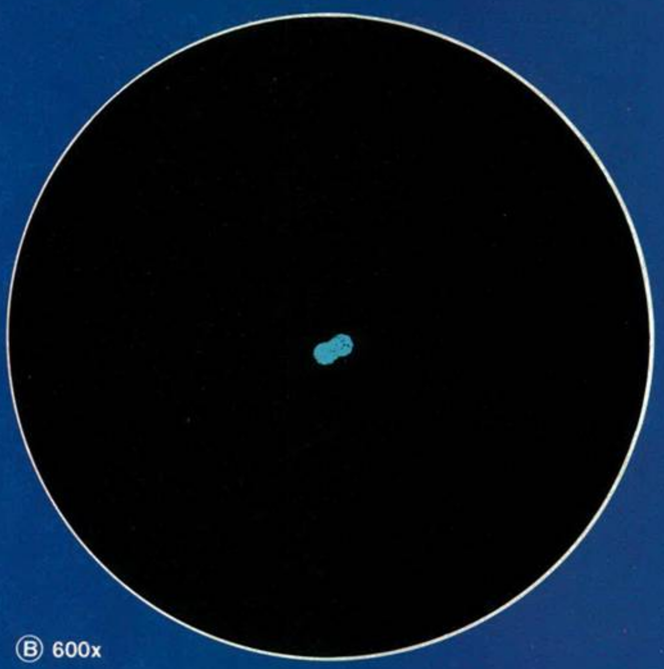
Eight inch and larger instruments reveal a subtle but definite color contrast between the two stars as well. Among the combinations reported are blue-white and orange, and blue and yellow. Webb, with his 9.3 inch reflector, saw the colors as pale yellow and lilac, while Barns, through a 10 inch reflector, saw them as amber and amethyst.

As mentioned in Close-Up, a seventh magnitude

Delta Serpentis



Iota Serpentis



**Binary systems of matched colors can be as exciting to the observer as more contrasted doubles. Diagram A shows Delta Serpentis, a binary consisting of two closely matched white suns, as seen through a three inch Unitron refractor at 90 power; the field is 1/2 degree. Iota Serpentis is a true challenge even to the experienced observer, as Diagram B shows. A 13 inch Fitz-Clark refractor at 600 power is sufficient merely to show an elongated, unresolved image — typical of close binaries below the resolution limit of a telescope. The field of view is about five minutes of arc. A much easier and probably more thrilling sight is the giant globular cluster-M-5, seen in Diagram C through a Celestron 5 at 50 power. The one degree field includes nearby 5 Serpentis. The cluster can be resolved nearly to its core. Drawings by James Mullaney.**

star lies in the same telescopic field with Beta, just to the northeast, providing a vivid scene. Strangely, the classical observers fail to mention this additional star in their descriptions.

The heavens are full of objects like Beta, with companions too faint or too widely separated for inclusion in double star lists. Many of these are lovely, especially at low power. Webb's **Celestial Objects for Common Telescopes** mentions many such pairs and combinations, but Webb himself admitted that his list only hints at the vast multitude of such objects. In fact he implored some zealous lover of the heavens to scan the sky and compile a roster of neglected and overlooked pairs, groups and star chains. More than a century later, his plea remains unanswered.

### Iota (ι) Serpentis

The third member of our binary trio is one of the most difficult visual objects in the heavens and offers a challenge of cosmic proportions to both observer and instrument.

This is the rapid binary Iota Serpentis, consisting of matched 5.2 magnitude suns hugging each other at only 0.2 seconds of arc separation. The system has a period of just 21 years and its orbit on the plane of the sky is perfectly circular, resulting in a nearly constant separation.

The tiny angular gap between the two stars is beyond the resolution limit of all but the very largest instruments. However, given good seeing (image steadiness), a modern, diffraction-limited 8 or 10 inch telescope at a per-inch-of-aperture power of 50 or more will show an elongated or pinched image as illustrated in our drawing.

The major axis (long dimension) of this stellar egg will change its position angle noticeably during the course of an evening's viewing, giving the impression the binary is rotating before our eyes! This apparent rotation in the field of view is a result of Earth's diurnal motion on its axis, causing a change in orientation from hour to hour. Objects having some dimension, such as the moon, planets, constellation figures — or Iota Serpentis — rise and set on their sides but transmit the meridian upright in the sky.

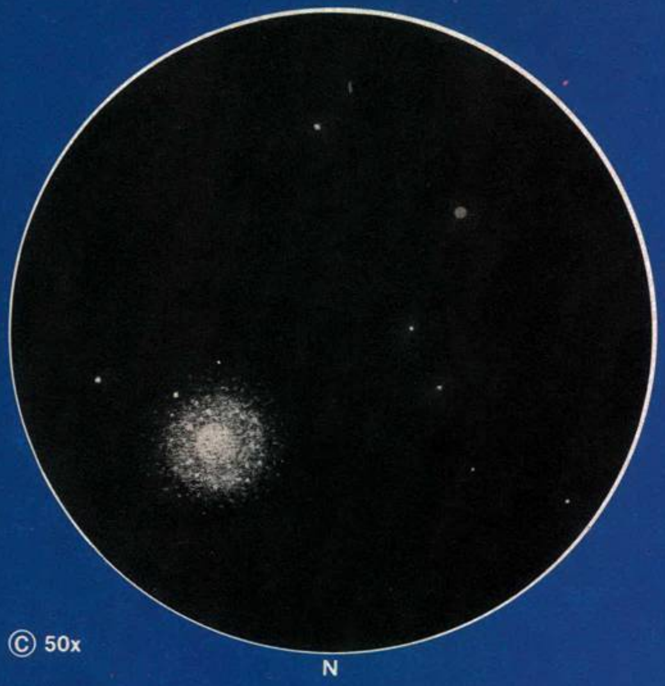
Why not put Iota to the test with your telescope on the next tranquil night? Even if you don't own a large instrument, try anyway: Wonders and surprises abound in the splitting of close double stars.

### M-5

For those who may have been discouraged by the challenge of our last offering, we present a spectacular object, sure to excite even the most casual stargazer. This is the globular cluster M-5 — a huge collection of stars swarming together into a tightly condensed ball.

As noted in Close-Up above, this showpiece is easily found in the same eyepiece field as the yellow

**M-5 and 5 Serpentis**



star 5 Serpentis. Many older lists place M-5 either in Libra or Virgo rather than Serpens; it lies near the point at which the borders of all three constellations meet.

Having an integrated or combined brightness of a sixth magnitude star (some authorities make it as bright as fourth magnitude), this remote globe of stars is visible with the slightest optical aid. A one degree, low power field of view includes both M-5 and 5 Serpentis. The latter object is a somewhat unattractive double star, the 5.3 magnitude primary having a 10.5 companion 11 seconds of arc distant.

In addition to the dramatic contrast 5 Serpentis provides with its neighboring cluster, it is also valuable as a focus check. Of all deep sky subjects, critical focusing is perhaps most important in viewing globular clusters with their multitudes of faint stellar pinpoints. It is often difficult to focus on the cluster itself, and a nearby field star of sufficient brightness must usually be sought. With M-5, we have a built-in focus star right in the same field of view.

At magnifications near 100 power, a good four inch telescope reveals three distinct parts to M-5; a dense blazing core, a ghostly surrounding halo of unresolved stars, and an over-sprinkling of individual stars or star groups, especially noticeable near the cluster's edges. Our drawing shows all three components, together with nearby 5 Serpentis.

In six to eight inch instruments, M-5 can be resolved in fleeting glimpses right into its center at 150 power or more, given a night of at least fair seeing. These apertures also allow the observer to trace streams of stars that trail off the edge of the cluster for a good distance. Some observers mention stragglers as far out as 5 Serpentis.

The view in 10 inch and larger telescopes is simply incredible and must be seen to be appreciated. The written word simply cannot convey the awe and majesty confronting the observer. For maximum effect in viewing rich globulars like M-5, nights of both good transparency and image stability are necessary. Poor seeing gives such clusters a washed-out look at the eyepiece.

At magnitude 6.2 and an angular diameter of 13 to 15 minutes, M-5 is a close rival to the famed Hercules cluster (M-13) in terms of visual attractiveness. Pickering, in his famous 1917 list of the sky's showpieces, said the appearance of M-5 was "But slightly inferior to that in Hercules." Most observers do in fact give M-13 the edge, for it is both brighter and higher in the sky. Both objects are considered to be "medium concentration" as globular clusters go.

Webb describes M-5 as a "Beautiful assemblage of minute stars, greatly compressed in center", and goes on to tell us that Messier could not resolve stars in this object with his telescopes, regarding it as a pure nebula.

Barns describes this marvelous object as a "Glowing compress of 9th to 14th magnitude stars." Other observers give the magnitude range as 11th to 15th, but the lower limit goes much fainter and cluster members have been photographed to at least 21st magnitude. Tens of thousands of individual stars can be seen visually and hundreds of thousands more picked up on photos. These stars include only the luminous supergiants — stars as small as our sun are totally beyond reach of the largest telescopes. In clusters like M-5, the actual number of member stars is estimated to be in the millions.

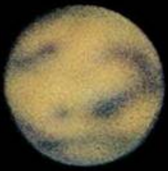
Many observers have called attention to the snakelike chains or loops of stars radiating outward in all directions from M-5. These are quite striking to the eye at the telescope but are largely lost in time exposure photos due to crowding. Pictures also tend to "burn in" the core of globular clusters giving no hint of the glittering aspect that atmospheric disturbances can produce on these objects. Indeed, most experienced visual observers prefer to view clusters like M-5 in large amateur instruments over the best observatory photos! No reproduction can ever match the thrill and excitement of viewing this kind of celestial glory with your own eyes.

At its distance of nearly 30,000 light-years, M-5 looms large on dark nights, saturating the mind with thoughts far removed from the cares and troubles of everyday life. As we gaze across the vast gulf of space at this colossal stellar commune, we may be reminded of the words of the poet Gerard Manley Hopkins: "Look at the stars! Look, look up at the skies! O look at all the fire-folk sitting in the air! The bright boroughs, the circle-citadels there!"

# Planet Finder

**Ⓒ Ceres**

| June | 1 | 15 |
|---|---|---|
| R.A. | 6h41m | 7h07m |
| Dec. | +27°05' | +26°50' |
| Mag. | +8.8 | +8.8 |

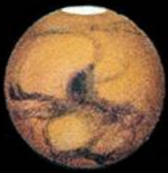


**Ⓐ Mercury**

| June | 1 |
|---|---|
| R.A. | 3h34m |
| Dec. | +15°26' |
| Mag. | +1.9 |

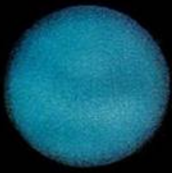
**Ⓑ Mercury**

| June | 15 |
|---|---|
| R.A. | 4h02m |
| Dec. | +17°10' |
| Mag. | +0.7 |



**Ⓜ Mars**

| June | 1 | 15 |
|---|---|---|
| R.A. | 8h48m | 9h21m |
| Dec. | +19°19' | +16°50' |
| Mag. | +1.7 | +1.8 |



**Ⓝ Neptune**

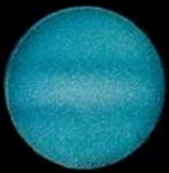
| June | 15 |
|---|---|
| R.A. | 16h43m |
| Dec. | -20°42' |
| Mag. | +7.7 |

SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

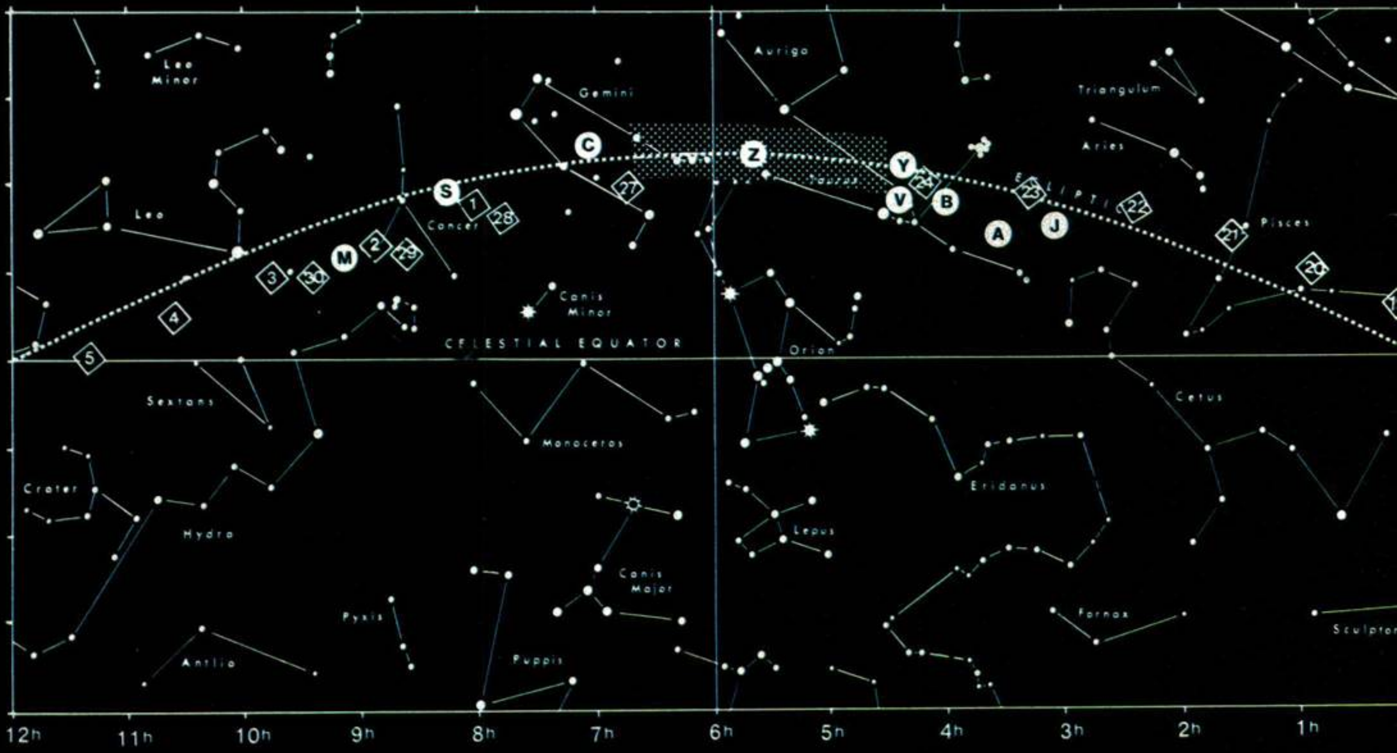
**Ⓢ Saturn**

| June | 1 | 15 |
|---|---|---|
| R.A. | 8h07m | 8h14m |
| Dec. | +20°39' | +20°20' |
| Mag. | +0.5 | +0.5 |



**Ⓤ Uranus**

| June | 15 |
|---|---|
| R.A. | 14h05m |
| Dec. | -12°09' |
| Mag. | +5.7 |


Leo Minor
Gemini
Auriga
Triangulum
Aries
Leo
Cancer
Taurus
ECLIPTIC
Pisces
Canis Minor
CELESTIAL EQUATOR
Orion
Sextans
Monoceros
Cetus
Crater
Hydra
Eridanus
Lepus
Canis Major
Pyxis
Fornax
Antlia
Puppis
Sculptor
C
S
M
Z
Y
V
B
A
J
1
2
3
4
5
20
21
22
23
24
27
28
29
30
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a

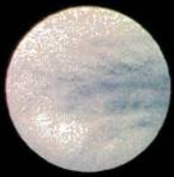
# June 1976

**Ⓥ Vesta**

| June | 1 | 15 |
|---|---|---|
| R.A. | $4^h00^m$ | $4^h25^m$ |
| Dec. | +16°51' | +18°06' |
| Mag. | +9.0 | +9.0 |

**Ⓙ Jupiter**

| June | 1 | 15 |
|---|---|---|
| R.A. | $2^h54^m$ | $3^h07^m$ |
| Dec. | +15°41' | +16°33' |
| Mag. | -1.6 | -1.6 |



**Ⓨ Venus**

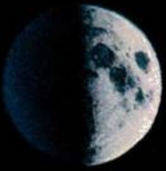
| June | 1 |
|---|---|
| R.A. | $4^h21^m$ |
| Dec. | +21°08' |
| Mag. | -3.4 |

**Ⓩ Venus**

| June | 15 |
|---|---|
| R.A. | $5^h35^m$ |
| Dec. | +23°29' |
| Mag. | -3.5 |

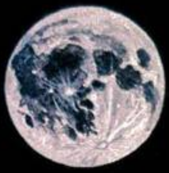
**Ⓟ Pluto**

| June | 15 |
|---|---|
| R.A. | $12^h58^m$ |
| Dec. | +12°18' |
| Mag. | +14 |



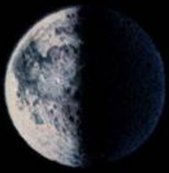
First Quarter

June 5



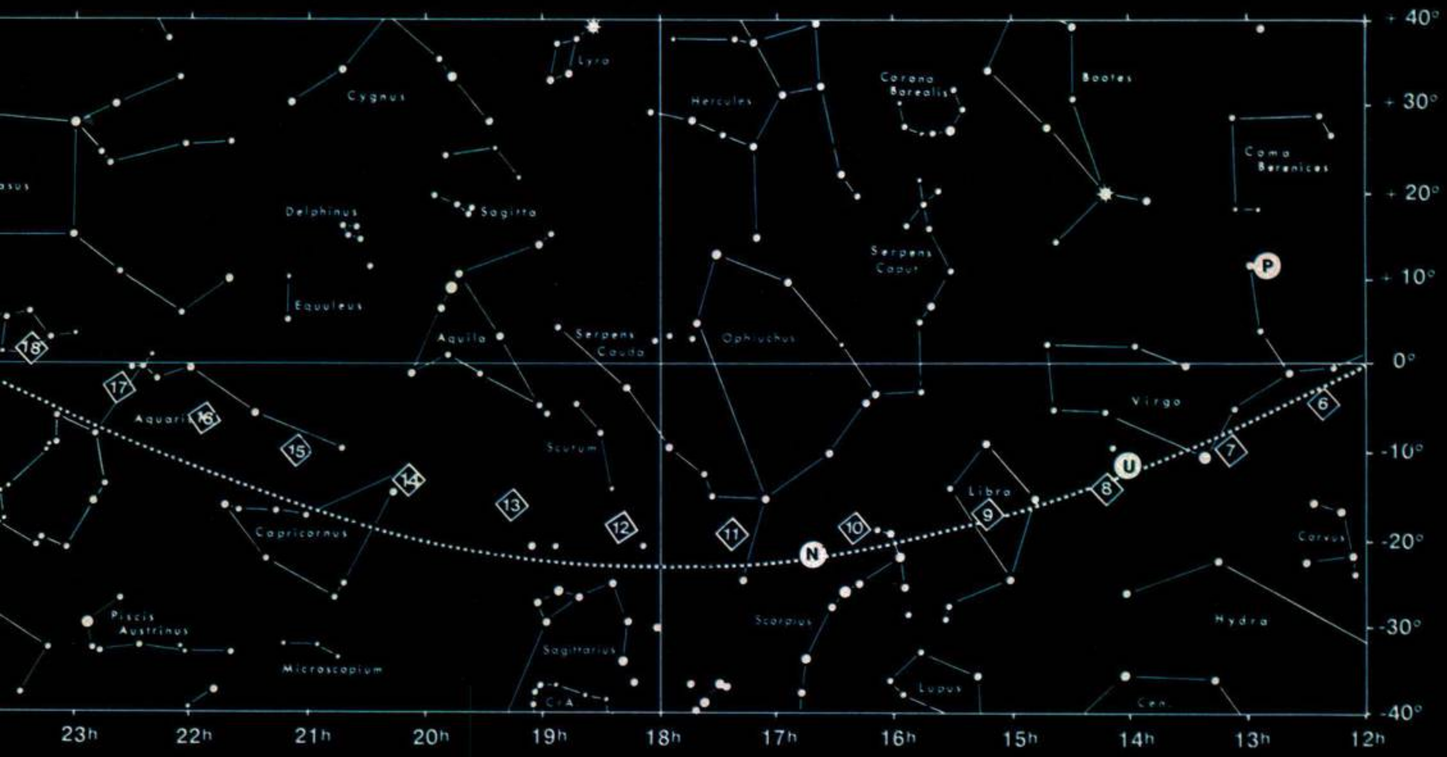
Full Moon

June 11



Last Quarter

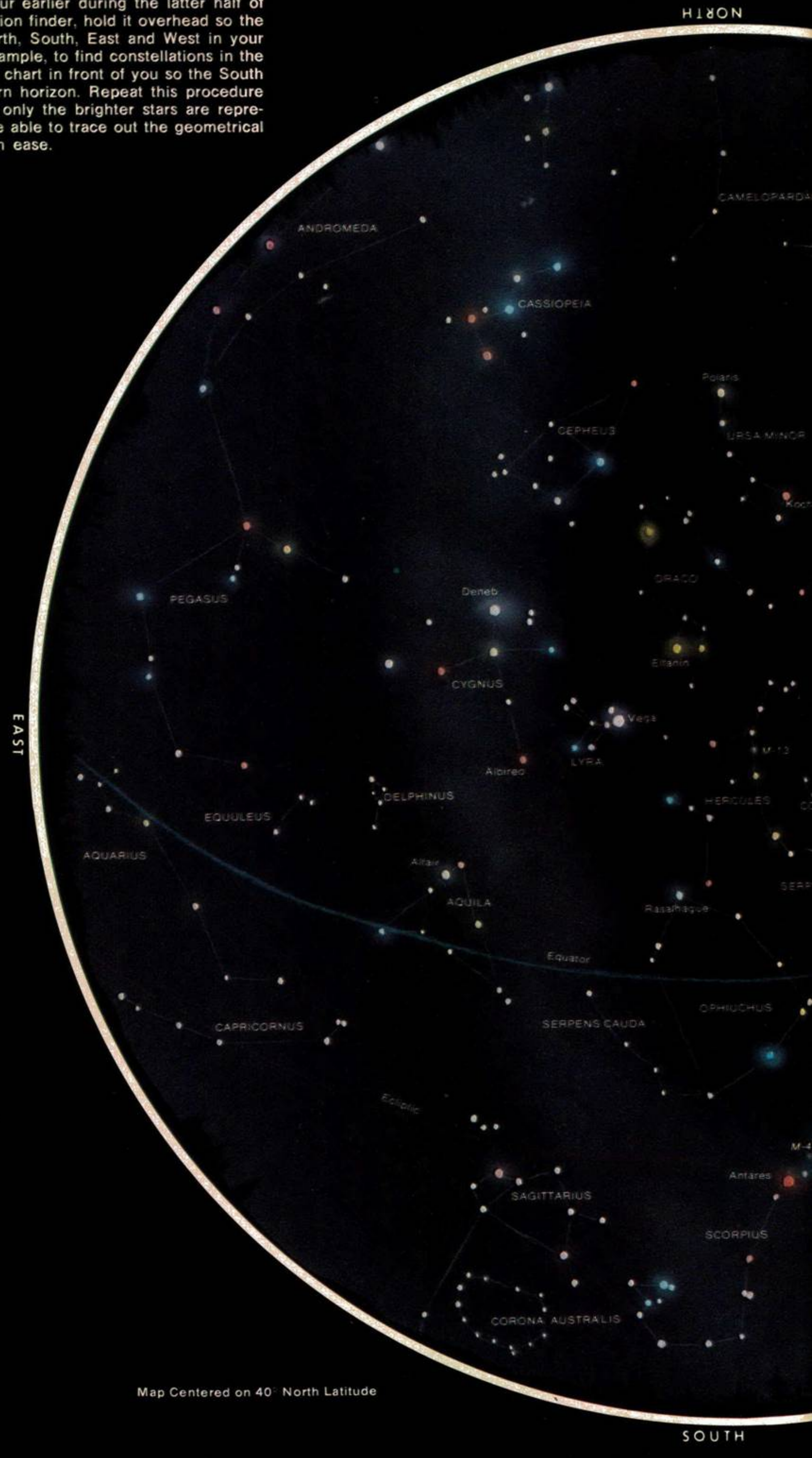
June 19



Lyra
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
asus
Delphinus
Sagitta
Equuleus
Serpens Caput
Aquila
Serpens Cauda
Ophiuchus
Virgo
Aquarius
Scutum
Libra
Capricornus
Corvus
Scorpius
Hydra
Piscis Austrinus
Sagittarius
Microscopium
Lupus
CrA
Cen
P
U
N
6
7
8
9
10
11
12
13
14
15
16
17
18
+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h

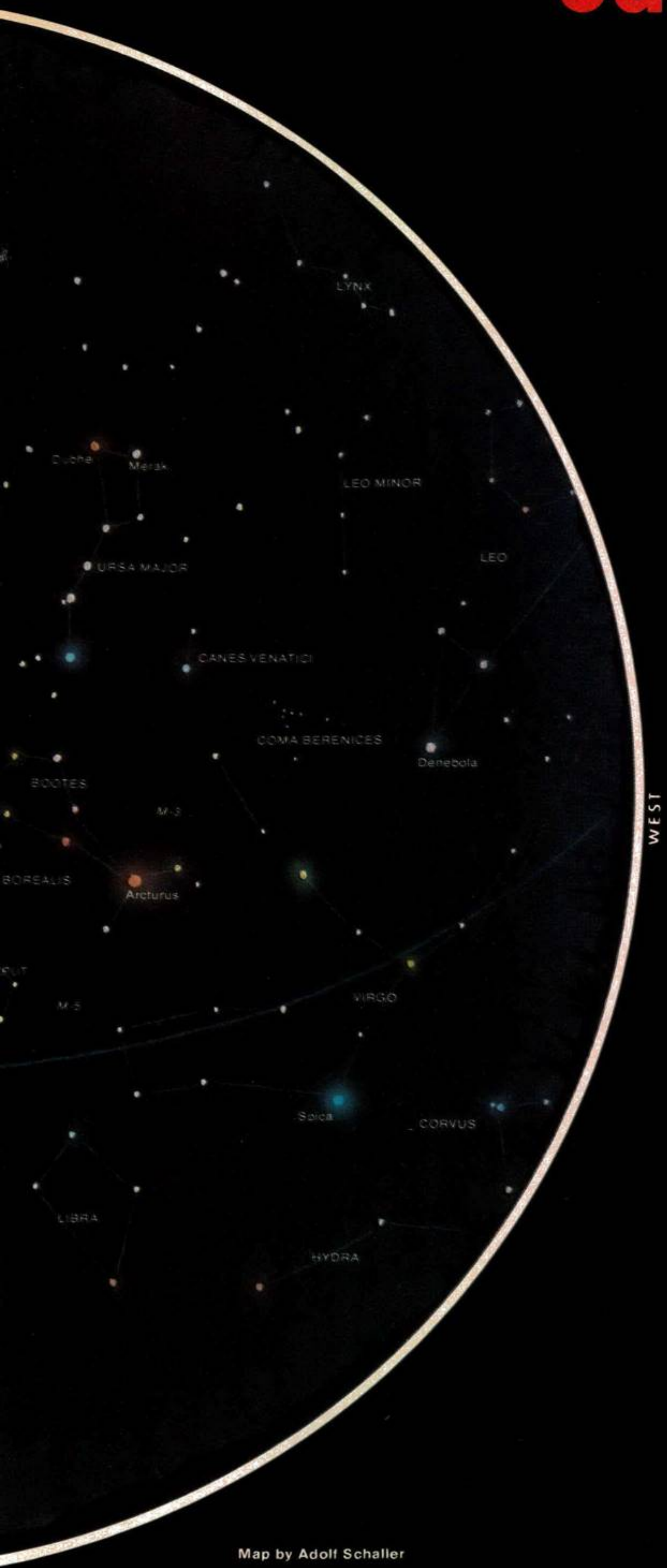
measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

This Star Dome rendering approximates the sky as it appears at about 11 p.m. Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease.


NORTH
CAMELOPARDA
ANDROMEDA
CASSIOPEIA
Polaris
CEPHEUS
URSA MINOR
Koch
DRACO
Deneb
PEGASUS
Eltanin
CYGNUS
Vega
EAST
M-13
Albireo
LYRA
DELPHINUS
HERCULES
EQUULEUS
AQUARIUS
Altair
AQUILA
SERP
Rasalhague
Equator
OPHIUCHUS
SERPENS CAUDA
CAPRICORNUS
Ecliptic
M-4
Antares
SAGITTARIUS
SCORPIUS
CORONA AUSTRALIS
SOUTH

Map Centered on 40° North Latitude

# July Star Map



Map by Adolf Schaller

Next month, ASTRONOMY presents its special bicentennial issue, featuring the History of American Astronomy. Owing to the length and special nature of this feature, all of ASTRONOMY's departmental features will be excluded with the exception of Sky Almanac and Planet Finder. Therefore, the monthly star map for July is being published in this issue.

The Milky Way returns to the sky during July evenings, with its brightest section in the constellation Sagittarius low above the southern horizon. Because of their low altitude, the Sagittarius star clouds may not seem as bright as those farther north — in Cygnus, for example — but observers in the southern hemisphere are favored at this time of year with a view of the Milky Way nearly overhead.

On the fringes of the Milky Way, passing across the meridian on July evenings, are the intertwined constellations of Ophiuchus the serpent holder and Serpens the serpent. These groups cover an immense area of the sky and would be far more dominant than they are if only they included a few more bright stars. As it is, the most luminous star in both constellations is second magnitude Rasalhague, which marks the head of the serpent bearer and is the most northerly star in the rough pentagon shape that makes up Ophiuchus.

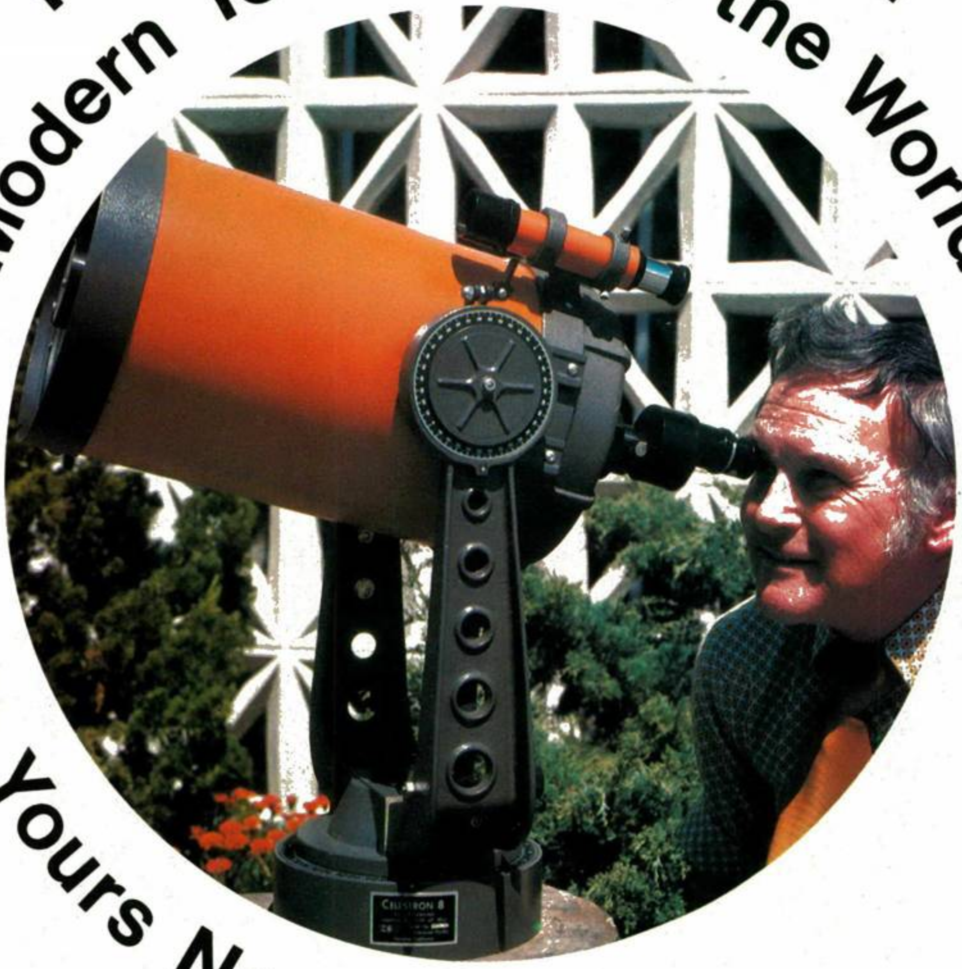
Ophiuchus is sometimes called Serpentarius. Both titles have the same meaning; the first is Greek and the second Latin for serpent holder. Usually depicted as a mature (even elderly) man grasping the coiling, twisting serpent in his hands, Ophiuchus has had several different indentifications over its long history. The most famous is that of Aesculapius, son of Apollo and the first man to practice medicine. So skilled did he become at his profession that eventually he was able to restore the dead to life. Hades, ruler of the underworld, developed the not-unreasonable-fear that his kingdom would soon be depleted of inhabitants, and he prevailed upon Zeus to strike the surgeon dead with a thunderbolt. Aesculapius was then transferred to the sky, where he could do no further damage to Hades' realm.

The connection between physicians and snakes has continued to this day. The doctor's traditional symbol (and the official emblem of the American Medical Association) is the caduceus — a rod or wand around which are twisted two snakes.

Star groups such as Ophiuchus, with no distinctive pattern or very bright stars, are surprisingly numerous in our skies, leading the casual observer to wonder how the ancients happened to gather the stars into these, and no other, groups. Until older records are discovered, the question will remain unanswerable.

**The Celestron 8**

# This is the Most Popular Modern Telescope in the World



## It's Yours Now for $790

The increasing popularity of the Celestron 8 has again made it possible for us to reduce the base price of this prestigious instrument. The base price of the Celestron 8 has now been reduced from $895 to $790.

Year after year the popularity of the Celestron 8 has grown steadily among professional astronomers as well as amateur astronomers and casual observers. The reason, in part, is a continually growing awareness of the superior optics and the usability of this fine telescope.

The optics of the Celestron 8 are guaranteed and *proved by laser interferometry* to be 1/30th-wave-r.m.s. or better. (For a small fee, we will provide you with photographic proof of the optical quality of your Celestron 8.)

The usability of the Celestron 8 lies in its compact portability (23 lbs., 22″ swung down) and in its versatility. With its massively stable fork mount, setting circles and electric clock drive, this telescope shows you the intricate swirls of the Great Orion Nebula in deep space as easily as it shows you the whiskers of a chipmunk at 35 feet.

As a result, today, among telescopes of modern design, the Celestron 8 is Number One the world over, outselling every other instrument of similar class, aperture and price by a substantial margin.

We believe this trend will continue, as we continue to draw attention to the outstanding features of this fine telescope. In a few months, we will know. If the trend does continue, the base price of the Celestron 8 will remain at $790.

For more information on this instrument and other Celestron products, ask for your free color catalog. Write to Celestron International, 2835 Columbia Street, Box 3578-AM, Torrance, California 90503, U.S.A. Or telephone (213) 328-9560.

**Celestron**